JANUARY 26, 1956

MACHINE DESIGN

JAN 27

A PENTON PUBLICATION

Published Every Other Thursday

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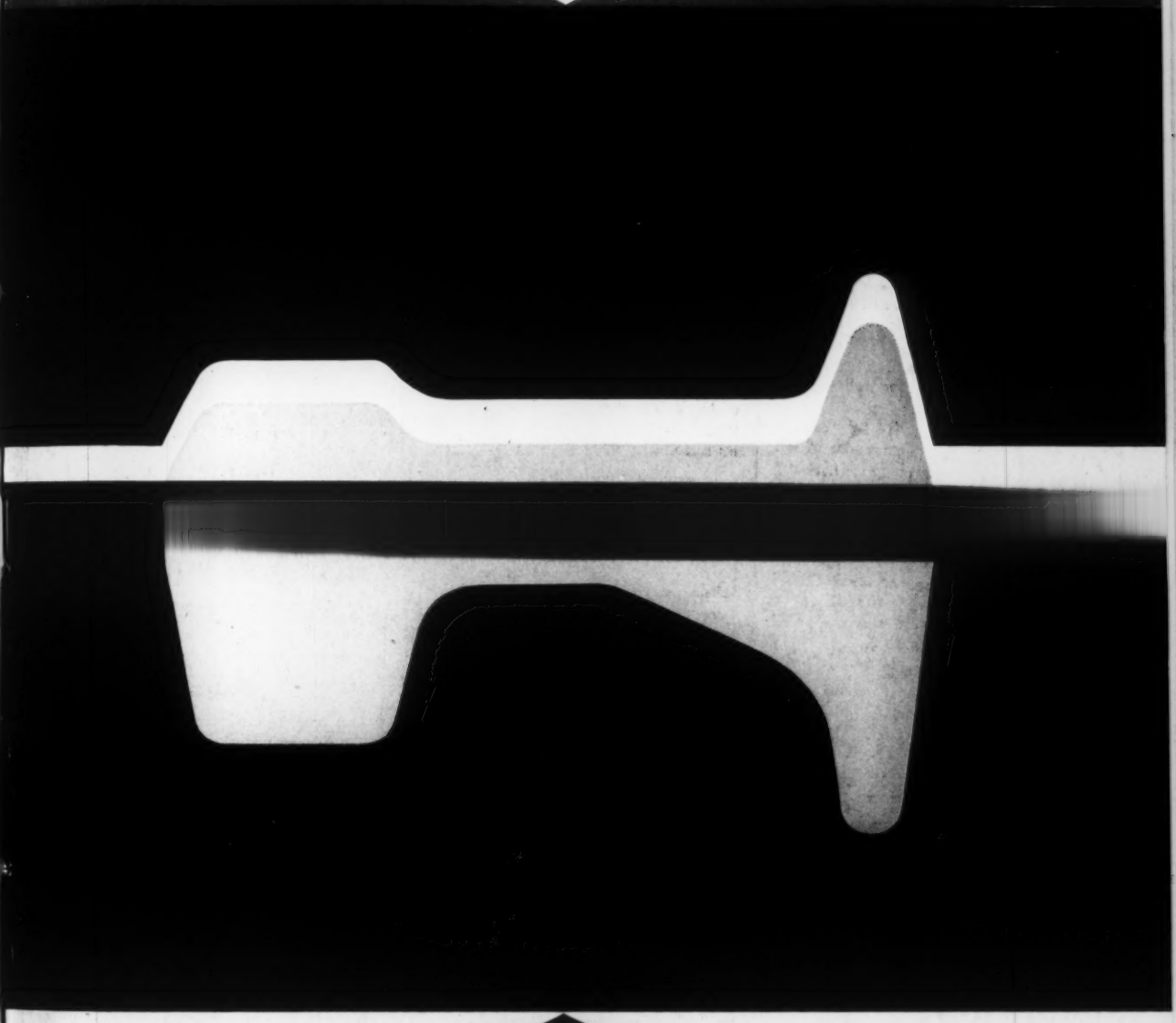

Aluminum Forging

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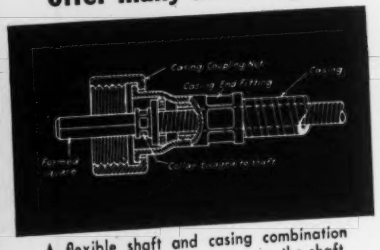
FLEXIBLE SHAFT IDEAS for ENGINEERS

Integral drive squares offer many advantages



A flexible shaft and casing combination with an integral drive square on the shaft.

THE integral drive square is formed by swaging the end of a flexible shaft into an accurate square. Used with broached or swaged square hole in the connecting member, the integral drive square is a simple, positive drive connection which can be used on either remote control or power drive flexible shafts.

Its use saves the cost of a machined end fitting and permits the use of a smaller, close fitting outer casing, two factors which lead to a reduction in the cost of the flexible shaft combination.

If you are now using flexible shafts or if you're working out a flexible shaft application it will pay you to investigate the possibilities of flexible shafts with integral formed drive squares.

S. S. White engineers offer valuable technical help

TAKE advantage of the advice and assistance of S.S.White engineers in working out details of your flexible shaft installation. They can save you time and money by recommending the most economical installation for your specific conditions.

There is no cost or obligation for this service. It enables you to get the benefit of S.S.White's long experience in the design and application of flexible shafts to all types of service.

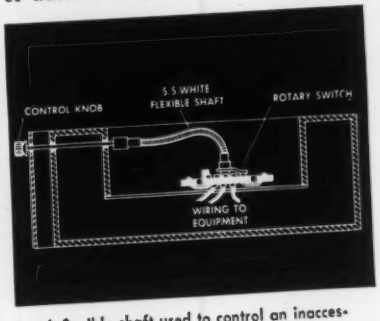
All details, of course, are held in strictest confidence.

Flexible Shafts are the key to many remote control problems

Space, operating and servicing requirements are readily met with S. S. White Metal Muscles®

MANY kinds of equipment contain internal elements which require more or less frequent adjustment from the outside. This comes under the heading of remote control.

There are various ways by which remote control can be accomplished. The simplest, of course, is to mount the element requiring control on the inside of the equipment case or housing with its shaft extending through for manual or automatic operation.

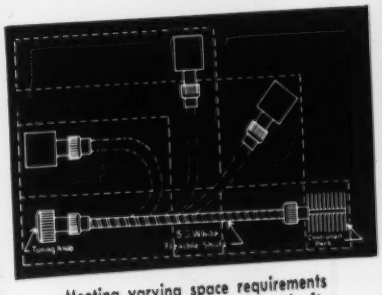


A flexible shaft used to control an inaccessible rotary switch. Note the 90° turn.

Flexible Shaft Simplicity

However, such direct connection is frequently not feasible. Factors of space, circuit efficiency, ease of assembly and of servicing must be considered. This applies also to the selection of the method of control to use.

An S.S.White Remote Control Flexible Shaft makes it possible to satisfy these requirements in an extremely simple manner. In place of comparatively complicated gearing, universal joints and similar contrivances, a single self-contained, easily applied flexible shaft does the trick.



Meeting varying space requirements is easy with a flexible shaft.

Design Freedom

But simplicity is only one advantage the flexible shaft offers for remote control. Perhaps its most valuable advantage is the freedom it gives the designer in locating the controlled element and its control knob or dial.

The flexible shaft permits the former to be placed wherever desirable to secure top equipment efficiency, ease of assembly, space saving and convenient servicing. At the same time it allows the control to be mounted in the most convenient operating position.

Another big advantage is the fact that it eliminates the need for accurate alignment of connected parts.

FLEXIBLE SHAFT DATA

Bulletin 5601 has concise information on how to select and apply flexible shafts. Send for a copy.

PS-1

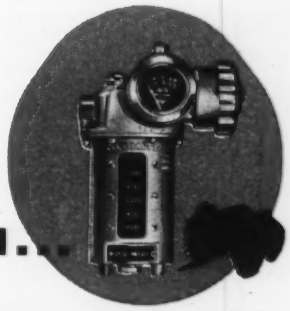
FIRST NAME IN FLEXIBLE SHAFTS

S.S.White

S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.

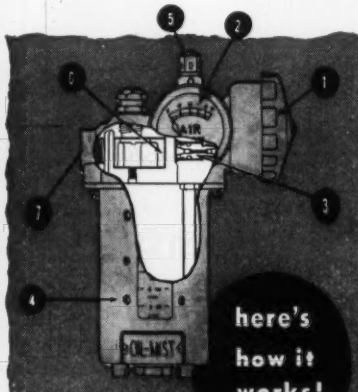
Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

A SIMPLE CONCEPT IN LUBRICATION...



that protects any machine... any bearing surface!

ALEMITE OIL-MIST



here's how it works!

This Oil-Mist lubricator atomizes oil into minute particles which are carried in the air stream through tubing to bearings. Compressed air enters through the air regulator (1) and air gauge (2). As the air passes the venturi (3) it draws oil from the reservoir (4). Oil flow is set by knob (5). The oil-air mixture is thrust against baffle (6), and only the tiniest, lighter-than-air particles are blown through the outlet (7) and through the delivery line to bearings.

Proved in countless applications—
multiplies bearing life—slashes product spoilage—boosts machine output!

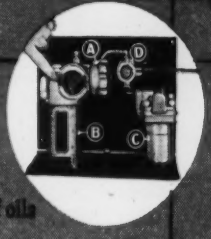
It's a simple idea in lubrication, and like most simple ideas, it's very sound. Easy to incorporate into new designs, equally easy to apply to machines already installed. Oil-Mist applies a constant, clean, cool film of oil uniformly to working parts—bearings, slides, vees, chains, gears—wherever needed. And in the form needed: Liquid, spray or mist. Replaces grease systems. No moving parts—operates on compressed air—completely automatic, fool-proof!

Three types of bearing fittings allow the use of OIL-MIST on any machine!

Oil-Mist fittings bring the most efficient lubrication in the world to any anti-friction bearing—roller, ball, needle.

Spray fittings are recommended for open and enclosed gears and chains. Allow for a concentrated spray of oil where needed.

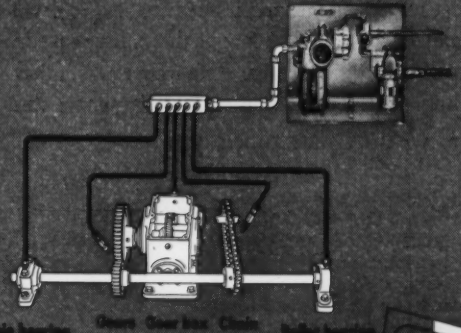
Condensing fittings apply oil in liquid form to plain bearings, slides, ways, vees, cams and rollers.



Lubricator Specifications

- Air regulator (A) reduces from pressures up to 200 psi. Normal air consumption, .7 to 1.2 cfm.
- Operating pressure, 5 to 20 psi. • Range of oils handled: to 1,000 sec. (S.U.V.) @ 100°F.
- Oil reservoir (B) capacity 12 oz. (One week's average supply) • Baffle-type water separator (C) is automatic—self-dumping.
- Solenoid Control (D) starts system as machine starts.

Complete range of models and multiple unit models—Capacities 12 oz. to one gallon to fit any application!



Alemite Oil-Mist offers these lubrication advantages

Automatic lubrication • Continuous lubrication
Eliminates guesswork • Greater safety • Cuts oil consumption up to 90%
Extends bearing life • Stops oil drippage • Saves man-power
Reduces number of lubricants needed • Eliminates "Down-time"

ALEMITE OIL-MIST LUBRICATION

A PRODUCT OF SW STEWART WARNER

FREE ...write today!

Use coupon below for your free copy of the Oil-Mist catalog and data book!

Alemite, Dept. R-16, 1850 Diversey Parkway, Chicago 14, Illinois

Name .....

Company .....

Address .....

City ..... State .....

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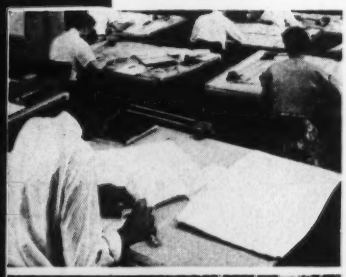
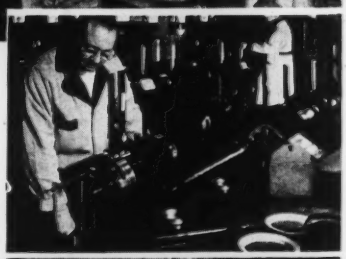
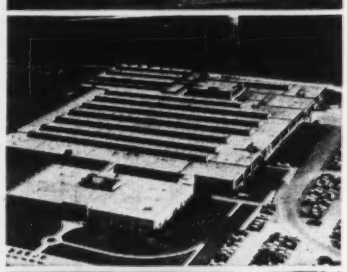
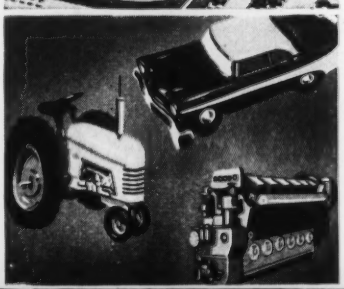
For More Information Circle Item Number on Yellow Card—page 19

Here's how C/R COOPERATIVE RESEARCH can help you









HELP YOU ENGINEER YOUR PRODUCT, ELIMINATE TOUGH TROUBLE SPOTS AND SAVE YOU MONEY IN FLUID SEALING AND RELATED FIELDS

Developing a new product or rectifying trouble in a present one? Why not supplement your own engineering facilities with C/R Cooperative Research? In the areas related to oil seal design, lubricant, chemical, gas, or air retention, and foreign matter exclusion—as well as in the development of synthetic rubber and impregnated mechanical leather parts—Chicago Rawhide's developmental facilities are the most extensive in the country.

All of them are at your service . . . for help with your critical or unusual problems. You may be sure that your design specifications, performance requirements, and production controls will be met to the letter. A few of the many ways in which C/R Cooperative Research serves other leading manufacturers are pointed out on this page. We'll be glad to help you.

INFORMATION . . . Comprehensive brochures and catalogs are available to give you the complete scope of C/R products and services. Write for your copies, and please indicate your area of interest.

DESIGN . . . When your product is on the drawing board is the time to correlate design and materials with performance requirements. C/R's expertly-staffed engineering groups working in close cooperation with the material labs have done it for others . . . and can do it for you.

MATERIALS . . . Pioneers in the development of Sirvis (mechanical leather) and Sirvene (synthetic rubber) parts for oil seals and other mechanical applications, C/R will custom-develop materials for your special needs in our synthetic rubber or leather laboratories.

PRODUCT TESTING . . . Many products, new and present, need extensive checking. C/R testing labs often work many months to verify designs, eliminate trouble. This is standard procedure on all C/R stock products . . . essential in developing yours.

TROUBLE SHOOTING . . . Auto and heavy equipment makers, as well as manufacturers in most fields you can think of, have solved difficult sealing and related problems with the help of C/R Cooperative Research. You can, too . . . and save time, trouble and money.

PRODUCTION . . . Six plants, operating as extensions of C/R Cooperative Research, provide laboratory-like quality control, timed to your needs. C/R Sales Engineering follows through to coordinate and assure satisfaction.

EXPERIENCE . . . Broadest in the field. Proof? More automobiles, farm equipment and industrial machines rely on C/R Oil Seals than on any similar sealing device. C/R diaphragms, boots and gaskets are in the same top categories.

C/R

CHICAGO RAWHIDE

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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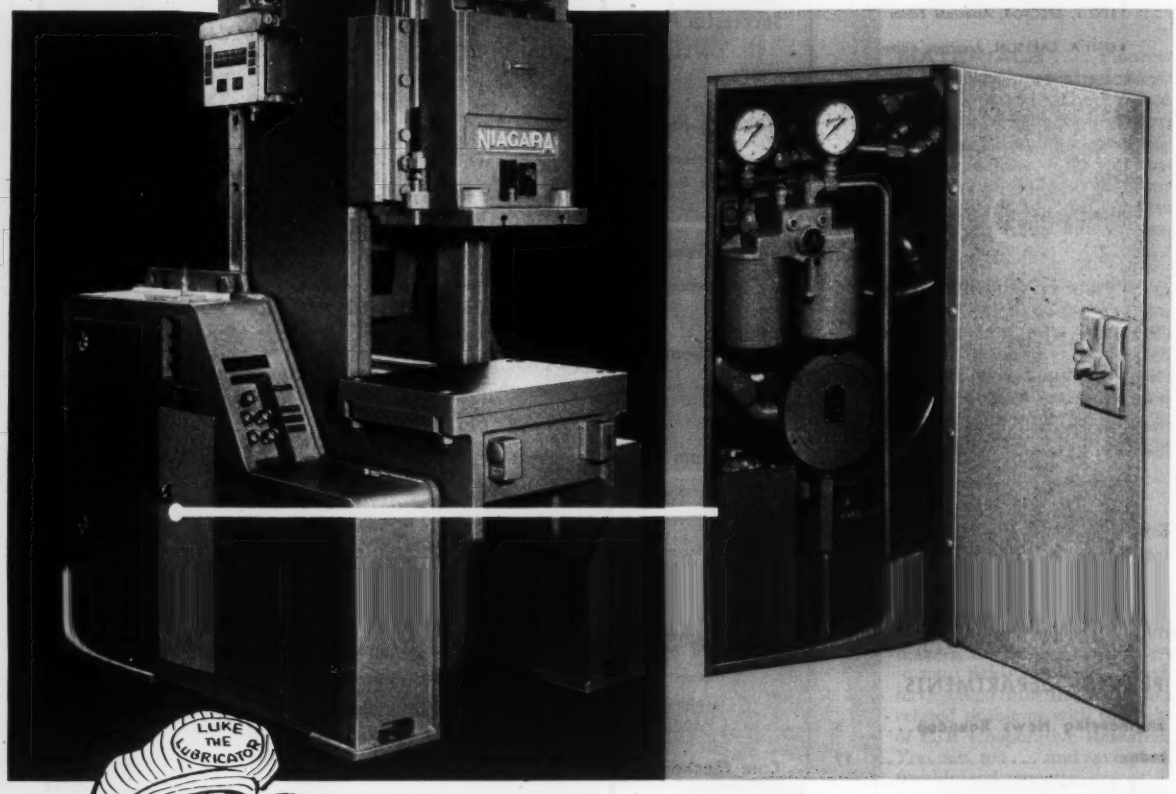
MASTERFUL ENGINEERING . . . . . Trabon Meterflo

AUTOMATIC LUBRICATION ON NIAGARA INCLINABLE PRESSES



TRABON "METERFLO" systems automatically circulate clean, filtered oil under pressure to all bearings; air counter-balance; and slide gibs, on the new Niagara front-to-back crankshaft open back inclinable presses illustrated.

TRABON'S exclusive warning devices react immediately to the inability of any bearing or line to receive oil. The positive progressive action of the piston type distributors is stopped, causing pressure switch to stop the press.

Another example of the application of the World's Finest Automatic Lubrication for Automation or Single Purpose equipment.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

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For More Information Circle Item Number on Yellow Card—page 19

Engineering News Roundup

Electronic Computer Field Expanding

New Applications Foreseen At Chicago Symposium

CHICAGO — The consensus of engineers, scientists and industrialists speaking at the second annual Computer Applications symposium in Chicago recently was that present applications of the electronic computer have just scratched the surface of this field.

Speaking on high speed computation of engine performance, J. T. Horner, supervisor of engineering calculations for General Motors' Allison division, discussed the merits of computers for handling engineering problems and the programming methods and procedures involved.

"Although we are using three different types of computers at the present time," Horner said, "we do not consider that our operations are as effective or economic as they will be made in the future."

He anticipated such improvements as development of symbolic internal computer codes, much larger and more compact high-speed internal memory, and increases in speed in the computation devices of the future.

On the other hand, John L. Marley, head of the Chicago management consulting firm bearing his name, cautioned that companies should not jump into the field of electronics without a long, appraising look at the economic factors involved in converting to automatic computers.

He suggested that before converting to electronics the company consider the type of computer to use and whether the field is moving too fast to appraise the situation in the proper light.

T. M. Bellan, supervisor of the department of applied mathematics at McDonnell Aircraft corporation, St. Louis, reported that the use of large-scale high-speed automatic computing devices of both analog and digital types has become a standard operating procedure for the engineering divisions of aircraft manufacturers.

"New frontiers have been opened as a result of advanced develop-

FINGER-TIP CONTROL is said to be an exclusive feature of this new Allis-Chalmers Forty-Five Motor Grader. Toggle-type linkage in the grader's control box provides leverage for smooth operation of moldboard, wheel lean and scarifier. Powered by a 216-hp diesel engine, the grader can travel 20.6 mph forward and 7 mph in reverse. It has combination mechanical and hydraulic power steering and an accelerator-decelerator pedal that permits increase or decrease in engine speeds without change in position of hand throttle. Operator's platform provides good visibility

ments in propulsion systems," Bellan stated. "The unknown has to be more thoroughly investigated. Detailed lengthy calculations are required on many of these explorations."

W. F. Otterstrom, controller, Montgomery Ward and Co., indicated that Ward foresees more applications in the accounting field. He cited these examples: more scientific placement of the 50,000,000 catalogs distributed each year, selection of the merchandise for make-up of merchandise lines, most profitable allocation of selling floor space, and sales and inventory forecasting.

MYSTERE, the latest Ford experimental car, features rear fins, a hinged glass roof canopy, steering wheel that can be positioned in front of either front seat, and rear-engine compartment designed to accommodate either a gas turbine or conventional engine. At center of the roof, the two canopy sections join at a steel bar linked at the front to a scoop which takes in fresh air for engine and passengers. Of the four headlights, one pair is for city driving, the other for highway operation. Mystere provides radio-telephone communication and has spherical instruments under a full safety crash pad

Transistors Control Giant Strip Mill

High Speed Operation Is Self-Adjusting

PITTSRURGH, PA. — Thickness of sheet steel is held to close tolerance by a transistor operated regulating system. Designed by General Electric Co., the unit is in operation at the Irvin Works of U. S. Steel Corp.

The transistors control the speed and rolling pressure of a five-stand mill. Speed of the steel strip is 3800 fpm. Main drive motors controlled by the transistor-operated device are rated at 3000 hp.

According to GE engineers, the system is self-inspecting and automatically compensates for product and operational variations.

Heat Exchanger Is Made of Glass

Product is Visible and Free of Contaminants

CORNING, N. Y.—A Pyrex glass shell-and-tube heat exchanger was shown in actual operation for the first time recently by Corning Glass Works. Four modules of a 13½ sq ft capacity heat exchanger were mounted horizontally in series, and liquids were pumped through both the tube and the shell size. A three-module bank of a larger, 50 sq ft shell-and-tube heat exchanger was also shown.

Developed by Corning for processing industries where resistance to corrosive acids and product purity are pre-requisites, both the shell and tubes of these units are designed to resist corrosion of all acids except hydrofluoric.

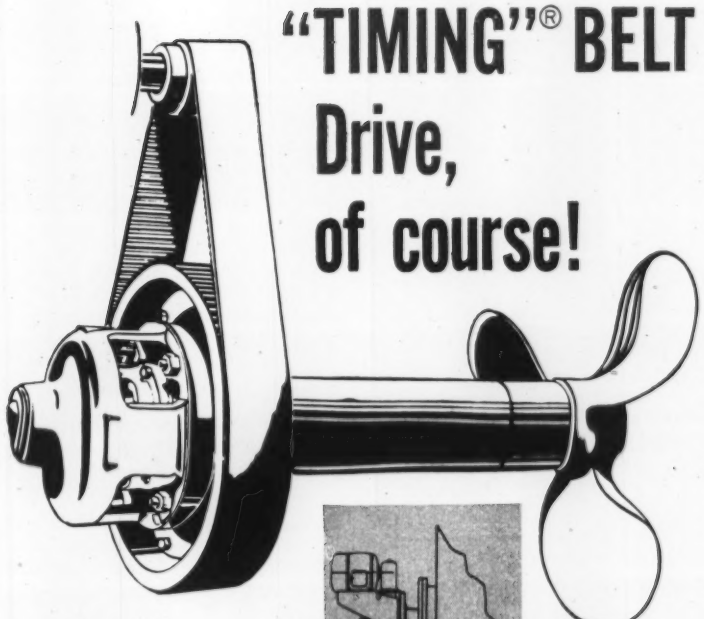
Complete visibility of the entire module helps guard against conduction losses by algae or scale

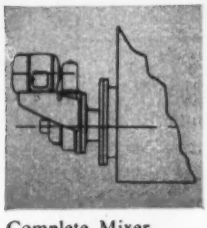
Front Cover

Tremendous forces and pressures involved in forging metals are highlighted by cover artist George Farnsworth. Featured article is by A. E. Favre of Alcoa on aluminum forgings, both standard and precision types.

What other single design improvement yields so many selling features?

adopting a Gilmer** "TIMING"® BELT Drive, of course!





Complete Mixer installed on side of tank.

*Jensen Engineering Company, Tulsa, Okla.

**The ORIGINAL Timing Belt.

A good example is the *JENSEN Model "BA" Shortstir Mixer**. Here is a simple 4-1 reduction drive from motor to propeller shaft...yet look at all the new selling features the adoption of a Gilmer "TIMING" BELT Drive provides the manufacturer! (The quotes below are taken verbatim from Jensen's *own literature.)*

"The JENSEN Shortstir Mixer, using the Timing Belt Drive, introduces a simple, rugged method of transmitting power from the motor to the propeller. It is much more compact, weight is greatly decreased, and elimination of couplings provides considerably less overhang from the motor.

"Motor alignment is set at the factory and a 'single bolt' adjustment for initial belt tension is the only adjustment required for the life of the belt.

"A Nylon facing and steel cable tensile members assure an almost unlimited belt life. Positive engagement of belt teeth with pulley grooves prevents slippage, power loss, and overloaded bearings common to most types of belt drives. Compactness greatly reduces vibration.

"No lubrication or belt dressing is required. Oil, however, does not harm the belt. All the advantages of a positive gear drive are accomplished plus the quietness and economy of a belt drive."

Stock or special Gilmer "TIMING" BELT

Drives are obtainable through your local NYB&P Distributor. Many design engineers are now making profitable use of the 200-page "Timing" Belt Drive Engineering Handbook. If you are engaged in designing machinery and do not have a copy, write us on your company letterhead.

Gilmer V-BELTS AND "TIMING®" BELTS

NYB&P INDUSTRIAL RUBBER PRODUCTS

NYB&P — NEW YORK BELTING & PACKING CO. Founded 1846

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

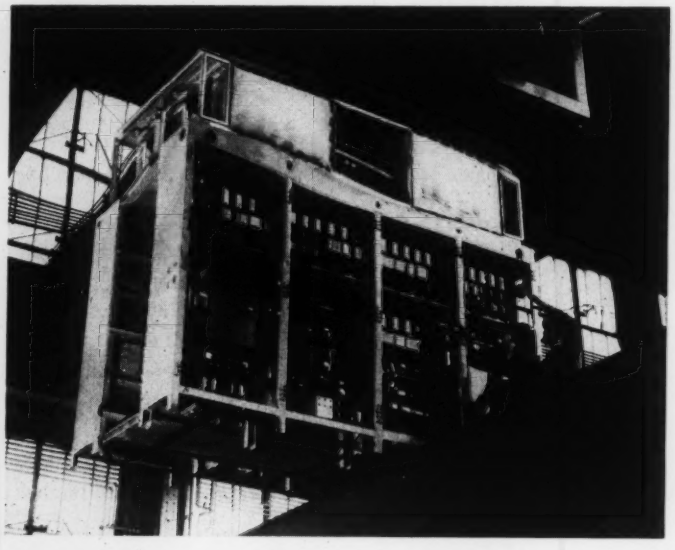
America's Oldest Manufacturer of Industrial Rubber Products

—ITEM 157—

formations on the tube side, and insures against product impurities. The unit can be cleaned by recirculating a dilute solution of hydrochloric acid. Straight-line flow and smoothness of the glass help reduce friction loss.

Main body of the module is standard 6-inch Pyrex glass pipe. A 26-tube bundle of ¾-in. thin-wall glass tubing is supported inside the pipe by baffle plates, creating a cross-flow of nearly 100 per cent over the tubes.

Operating temperatures up to 375 F are possible on the shell side of the Pyrex heat exchanger and 200 F on the tube side; operating pressures can be as high as 20 psi. The light-walled tubes have a heat conductivity coefficient of 260 BTU/hr/ft²/deg F.



PREASSEMBLED CONTROL shown here is going into an electric locomotive. General Electric Co., designers of the control, found it easier to assemble it in one unit outside the locomotive, thus eliminating working in cramped quarters. After the entire unit is assembled, it is lowered into place

Fog Where It's Wanted Is Produced by Gas Turbine

SAN DIEGO, CALIF.—New applications of gas turbine engines—ranging from deicing to fog generation—are increasing the usefulness of this new power source, Solar Aircraft Co. reported recently. In one test, the exhaust heat of a Mars gas-turbine fire pump was used on a Navy ship in the Arctic to remove ice from deck, bulkheads, anchor chains and hawse pipes.

Another test employed the Mars unit as a fog generator. It was found that the Solar turbine's exhaust heat, used to vaporize fog oil, generated about four times as much fog as conventional apparatus of the same weight.

Power source of the fire pump is the basic Mars gas-turbine engine, a 50-hp unit weighing less than 100 lb and smaller than a 2-ft cube.

Anderson Brass Co., Detroit, has recently acquired certain assets of the Brass Div., Detroit Brass and Malleable Co., according to R. C. Anderson, president of Anderson Brass. Brass Div. makes gas cocks, valves and fittings which will continue to bear their present trademark.

Topics

Nothing new under the sun? A recent report reveals that the British are building diesel-electric paddle-wheel boats for tugboat service. They have exceptional maneuverability say the British engineers.

• • •

Boeing's 707 jet airliner, not yet in production, has already been superseded by a larger model. Passenger-carrying capacity has been increased from 104 to 148. Larger engines capable of about 15,000 lb thrust are reported being considered for the plane.

• • •

Ben Franklin's experiments with electricity have been recognized by the Post Office Dept. A three-cent stamp recently issued shows Ben drawing a healthy arc from a key on his kite string.

• • •

A Texas Dodge is available for sale exclusively in Texas. This two-door hardtop features crossed Texas flags on the hood and a chrome outline map of the state on the dash and rear fenders. The name "Texan" appears in chrome script over the outline map. This opens the way for at least 48 more models in addition to the dozens of combinations presently available.

• • •

Plymouth enters the sports car field with its new 240-hp "Fury." They call it that because it goes like fury, according to Plymouth's advertising dept. The field is now open for new names, depending on what the cars go like.

• • •

Utter bilge. That's what a prominent British astronomer has to say about interplanetary space travel. He bases his statement on the fact that no one has enough money to finance such a thing. Members of the British Interplanetary Society disagree. They say we'll be traveling to the moon within the next 20 years.

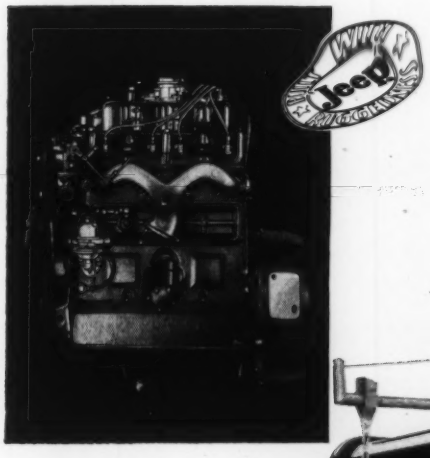
• • •

Dept. of Incomplete Stops: One of MD's editors, while on a recent plane trip, was intrigued by the stewardess' announcement, "Please keep your seats until the plane comes to a complete stop." He wonders if incomplete stops are peculiar only to aircraft, or do they occur among moving objects in general.

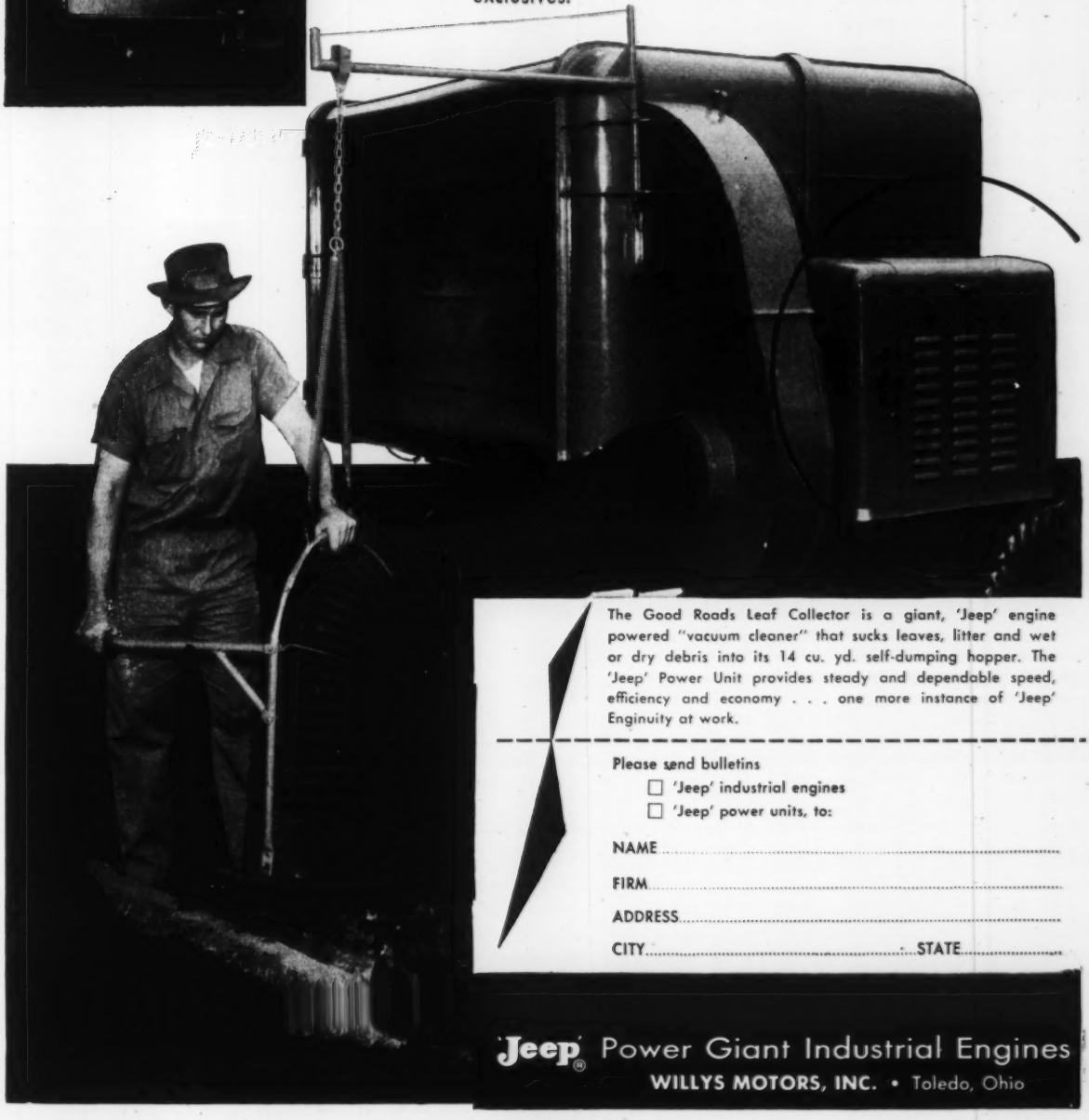
'Jeep'® engines . . . combat proven for industry's mightiest demands!

All these proven 'Jeep' features

for one of the longest-lived, most rugged four-cylinder Industrial Engines today!



It's the heart of a fighter, with a history of astounding staying power under back-breaking demands. Now this famous engine has been redesigned specifically for industrial needs. Here's why the 'Jeep' engine can do so much, and last so long, for so little expense, in your powered equipment: • Up to 70 hp in a 2-foot length; • Stellite valves with positive rotators; • Positive crankcase ventilation; • Large 2" intake valves in F-head design for extra breathing capacity, and countless other 'Jeep' exclusives.



The Good Roads Leaf Collector is a giant, 'Jeep' engine powered "vacuum cleaner" that sucks leaves, litter and wet or dry debris into its 14 cu. yd. self-dumping hopper. The 'Jeep' Power Unit provides steady and dependable speed, efficiency and economy . . . one more instance of 'Jeep' Enginuity at work.

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'Jeep'® Power Giant Industrial Engines

WILLYS MOTORS, INC. • Toledo, Ohio

FULL JET Douglas DC-8 to be built for Pan American World Airways is expected to be ready for service about December, 1959. Span of the DC-8's swept wings will be 134.6 ft, length 140.6 ft, and gross weight of the overwater version will be 257,000 pounds. Powered by four Pratt & Whitney J-57 engines, the airliner's cruising speed is expected to be 550 mph. Typical flight time between Los Angeles and New York will be 4 hours, 50 minutes

Survey Shows New Cars Use More Aluminum

Future Applications Expected To Continue Trend

DETROIT, MICH.—Weight of aluminum in the average passenger car has increased from 29.6 lb in 1955 cars to 35.2 lb in this year's models. A recent Alcoa survey indicates a record-breaking 246 million lb of the light metal will be used in 1956 passenger cars—if 7 million are produced as Alcoa economists estimate.

An important part of the increase appears as exterior trim—some in colors other than natural aluminum.

Looking ahead, Alcoa specialists "guesstimate" that aluminum applications on autos will rise to 49.8 lb by 1960 and to 81 lb by 1965.

Close to 50 per cent of the aluminum in passenger cars goes into automatic transmissions. Another major application of the metal is in the engine, now using 30 per cent of the total. Body trim accounts for 7 per cent and offers one of the most promising applications for future growth. Balance of the aluminum goes into miscellaneous applications such as wiring, brakes, power steering and air-conditioning units.

Aluminum in 1956 Cars

Make*	Standard Car (lb/car)	With Auto. Trans. (lb/car)	Auto. Trans. and Power Acces. (lb/car)
Chevrolet	13.15	15.26	15.26
Buick	19.97	58.98	59.28
Ford	17.27	34.50	....
Plymouth	21.23	57.23	68.18
Chrysler	....	65.17	76.12
Packard	19.8	78.3	....
Hudson Hornet	18.80	77.20	....

*All V-8's.

Die casting was the principal production method for aluminum auto parts. New models average 15.7 lb of aluminum die castings per car compared to 12.3 lb in 1955 models.

The next important advances for aluminum in automobiles may be for radiator fins joined to brass tubing. Eventually, auto radiators may be all aluminum. Engine blocks and heads are said to offer excellent possibilities, and brake drums and differential housing.

Free-Machining Steel Bar Requires No Heat Treating

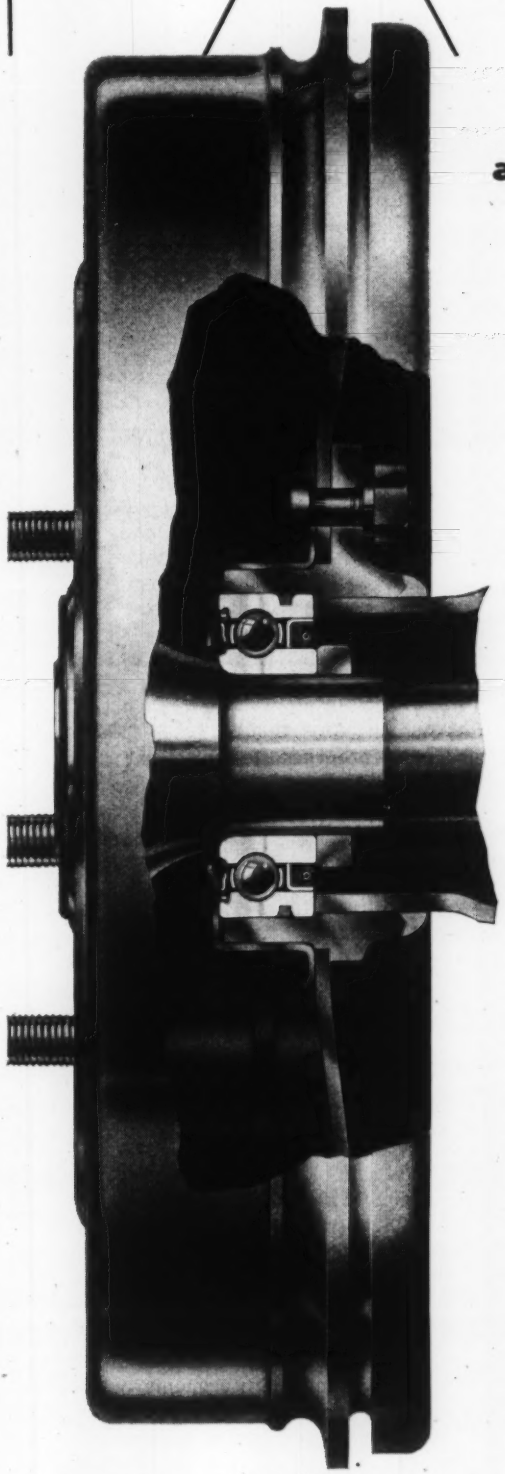
HAMMOND, IND. — A new, high-strength, free-machining steel bar which requires no heat treating has been announced recently by La Salle Steel Co. The new product introduced under the trade name Fatigue Proof has inherent properties usually associated only with heat-treated steels.

The new product has high machinability compared with heat-treated steels. It is said to machine at least 25 per cent faster

FACTS

about

NEW DEPARTURE
BALL BEARINGS



New Departure's Sealed-for-Life Rear Wheel Bearing is press-fitted to its seat—without need for locknuts, threads, or grooves to weaken the shaft.

30,000,000 rear wheel bearings can't be wrong!

This New Departure rear wheel application is an outstanding example of the advantages ball bearings provide designers for increased dependability at lower cost.

As proved more than 30,000,000 times, New Departure Rear Wheel *ball bearings* permit the design of simpler, stronger, more foolproof axle mountings . . . and the savings ball bearings bring in machining, assembly, and axle parts cut production costs substantially.

New Departure Rear Wheel Bearings, mounted this way, eliminate locknuts, threads, and grooves—never require adjustment. They are "Sealed and Lubricated for Life," giving the service-free qualities that have earned them the description "*built to be forgotten*" . . . and a reputation of outlasting the product they serve.

Remember—leading manufacturers depend on New Departure for outstanding *quality and engineering service.*

NEW DEPARTURE SEALED BALL BEARINGS
PROVIDE MINIMUM MAINTENANCE—LONGER LIFE
New Departure offers a wide variety of sealed ball bearings for applications of every kind. Full details on request.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

—ITEM 159—

than annealed alloys and 50 to 100 per cent faster than heat-treated alloys. Distortion from machining is held to a minimum, and surface finish is considered excellent.

Tensile strengths are in the range of 140,000 to 150,000 psi and hardness related to this strength level is approximately 30 Rockwell C. The bar also is said to have excellent wear resistance, good resistance to fatigue and service failures, a high degree of dimensional stability and freedom from residual stresses.

CONTINENTAL MARK II is the Ford Motor Co. successor to its distinctive Lincoln-Continental. The new elite car is designed for low-volume high-quality production. Styling is conservative, called "modern formal," and features a long hood, short rear deck and unique spare tire mounting. Standard mechanical features include automatic transmission, power brakes, power steering and power-operated vent and side windows. On a 126-in. wheelbase, the frame of the Continental is characterized by tubular cross-members which permit 4-ft. 8-in. overall height of car

Talking Elevator Can Raise It's Voice and Passengers Too

NEW YORK—An automatic elevator with the gift of tongues—Otis Elevator Company's *Elevoice*—was on exhibit recently in the Kingsbridge Armory, the Bronx.

The *Elevoice* not only makes directional and floor stop announcements such as "Going up" and "Out five, please," but also delivers special messages when a passenger delays the car's departure by obstructing the doors or in similar circumstances.

Any number of messages appropriate to an elevator's movements and to the building in which it is installed may be recorded electronically on one or more master drums.

Volume of the announcements can be adjusted by means of individual controls on each amplifier on the master drum. Thus, volume can be held to a minimum in schools, hospitals and libraries, or increased to be heard above the din of machinery in factories.

JET ENGINE STARTER is the vehicle that has crawled under this fighter craft. Made by North American Inc., the low-slung car is powered by a commercial gasoline engine and transmits starting power to the plane through a hydraulic torque converter. North American claims it starts engines faster than current types of starters and reduces the whining sound usually characteristic of the operation. The starter has four-wheel drive, four-wheel steering and can tow the planes it works with. Measuring 30 in. high, 144 in. long and 65 in. wide, the starter can be airborne. The chassis is made of tubular steel and has torsion-bar wheel suspension

New Technique Speeds Tube Brazing

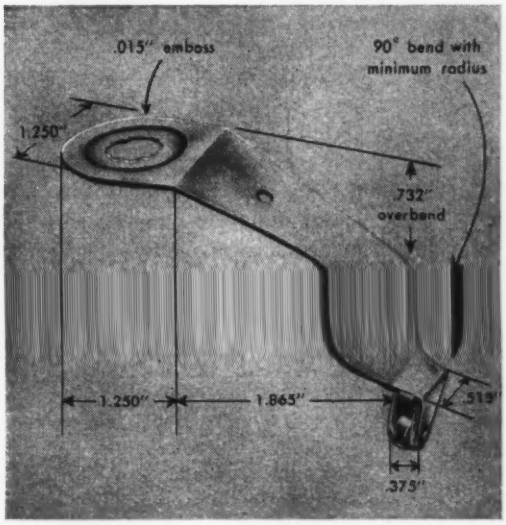
MANSFIELD, O. — A new method for brazing structural joints in steel tubing is reported to be faster and more economical than previous methods. Developed by Elyria Welding Service, the new method utilizes bronze beads for filler metal and applies the brazing alloy from the inside.

Basis of the technique is a special jig, a multiple-tip torch and the use of a flux-bearing flame.

After the assembly is secured in

This railroad runs better, will last longer

A Type ZW Lionel Trainmaster Control has four independent variable voltage circuits, can operate four trains simultaneously.



One of the four variable voltage taps in a Type ZW Lionel Trainmaster Control, now made of .0150" thick Duraflex in spring temper. This temper in Duraflex provides the extra strength needed—with the same forming properties as conventional phosphor bronze in extra hard temper.

Lionel switched to DURAFLEX for the hardest working parts of its Trainmaster controls

Much of the fun of model railroading depends on the smooth, dependable performance of its controls. That's why Lionel makes its Trainmaster controls tough, precision instruments – constantly guards their quality.

Lionel had been using an ordinary phosphor bronze in the vital, hard-working variable voltage taps. But they were troubled with fractures in forming the bends. To maintain their quality standards, they considered using another alloy, at substantially increased cost.

First, however, they tried Duraflex*, Anaconda's new superfine-grain phosphor bronze. The fractures were eliminated. The press room found the forming qualities of Duraflex excellent. The Transformer Department was pleased with the reduction in rejects, found the strength and resilience better.

So Lionel has controls of superior quality – at no extra cost – for Duraflex costs no more than ordinary phosphor bronze.

Duraflex, because of its superfine-grain structure, offers greatly improved fatigue resistance and formability. It also has a finer, smoother, harder surface, plus good electrical conducting properties and high corrosion resistance. It is produced in sheet metal up to 0.062" thick and in wire up to 3/16" diameter. We will provide free samples for test purposes – specify gage and temper. Write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5666

*Trade Mark

DURAFLEX

The New Superfine-Grain Phosphor Bronze

with 30% Greater Endurance Limit

an ANACONDA® product

—ITEM 160—

THIS IS IT!

The Quick-Connective Pneumatic Coupling that gives you these big advantages . . .

EFFECTIVELY HANDLES MORE VOLUME THAN ANY OTHER COUPLING OF EQUAL DIMENSIONS
HANSEN
OPEN
CAN BE USED ON ANY CIRCUIT WITH 3/4" TO 1/8" CONNECTIONS
ONE-WAY SHUT-OFF

HANSEN Series 3-RL

RING-LOCK COUPLING

• Compactly designed, the Hansen Series 3-RL Coupling *effectively* handles far more volume than any coupling of equal dimensions. On units where several air circuits are required, the single-size Series 3-RL Coupling—with correct size connections—can be used on any line with ¾" to ⅛" fittings—thus making it easy to keep stock of parts in balance—hold inventories to a minimum.

To connect, merely push Plug into Socket. To disconnect, just turn the sleeve—flow is shut off instantly and automatically. Locking ring provides positive lock and assures tight fit.

Representatives

BALTIMORE, BIRMINGHAM, BUFFALO, CHICAGO, CLEVELAND, DALLAS, DAYTON, DENVER, DETROIT, FT. WAYNE, HARTFORD, KANSAS CITY, LOS ANGELES, LOUISVILLE, MILWAUKEE, MINNEAPOLIS, NEWARK, NEW ORLEANS, PHILADELPHIA, PITTSBURGH, SAN FRANCISCO, SAVANNAH, SEATTLE, ST. LOUIS

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ACETYLENE • REFRIGERANTS
GASOLINE • COOLANTS

SINCE 1915 ® QUICK CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 11, OHIO

—ITEM 161—

News Roundup

the jig, brazing alloy in the form of bronze beads is poured into the vertical tube. By heating the entire joint simultaneously with the multiple-flame torch, molten bronze completely fills the joint leaving the outside surface clean. No grinding or brushing is required before finishing.

Square D Co., Detroit, and **Electric Controller and Mfg. Co.**, Cleveland have been merged recently. F. W. Magin, former president of Square D, is board chairman and A. G. Patterson, former president of Electric Controller, is president of the new Square D. Product lines of the merged companies include electric distribution and control devices in low voltage range and electric motor controls for heavy industries.

New Guided Missile Equipment Standards Sought

Committee Seeks to Reduce Failure Probability

WYANDANCH, L. I., N. Y.—Efforts to improve the over-all reliability of missile weapons systems through improved component reliability are being made by the major designers and producers of guided missiles, according to Edwin A. Speakman, chairman of the Guided Missiles Committee of the Aircraft Industries Association. Speakman, vice-president of the Fairchild Engine and Airplane Corp. stated that reliability is the greatest single problem facing the missile industry.

Component reliability is a limiting factor in today's missiles. The AIA Guided Missiles Committee, working with the military services and the suppliers of equipment—particularly electronic components—will seek to establish new standards for missile equipment. These standards will necessarily be higher than requirements of other industries, according to Speakman.

"In a missile," he pointed out, "no human is along to monitor and make adjustments. Therefore,

failure or malfunctioning of any single part among the thousands needed to make a missile can mean total failure of the missile. Component reliability is the key to greater reliability in the missiles themselves.

"The pyramiding effect of 'failure probability' can quickly lead to the point where the probability of a successful flight can reach the Zero point unless missile components are refined until their reliability rate nears the absolute," Speakman declared. "If, for a simple example, the average failure expectancy in electronic tubes, resistors, etc. was one per thousand and a missile contained 1000 electronic components, successful flight probability would be zero."

Tremendous advances have been made in the missile field in the past ten years, he said, adding that the greatest immediate progress could be made through improvements in reliability. Such improvements would be beneficial not only to present missiles but also to missiles not yet off the drawing boards.

Calculator Flies Punched-Card Airplanes

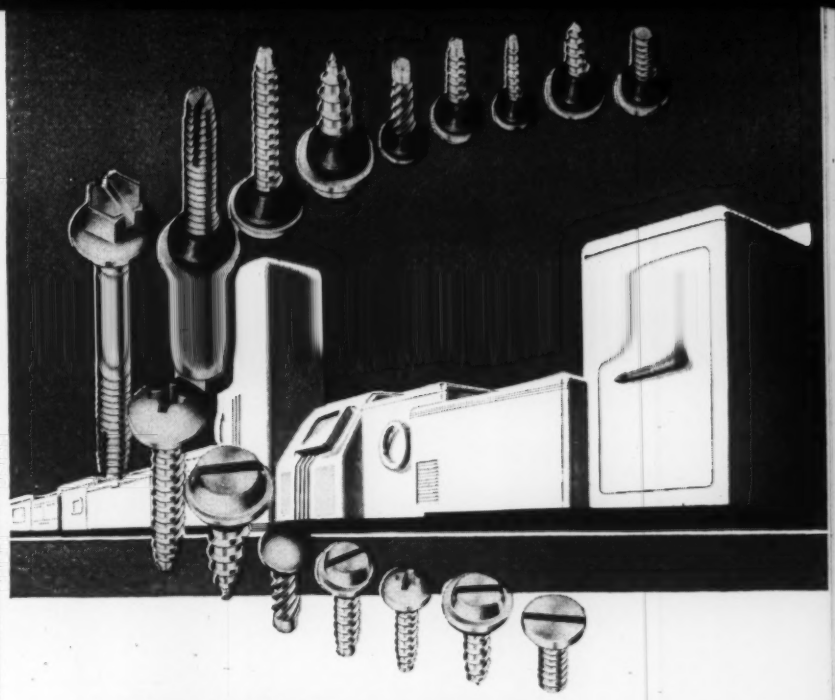
Ideas Given Simulated Flight Tests

SCHENECTADY, N. Y. — Punched cards containing airplane engine and airframe performance data are fed into a newly developed electronic calculator. In about 20 seconds, this information is absorbed by the computer, and an answer covering one phase of the airplane's performance is obtained.

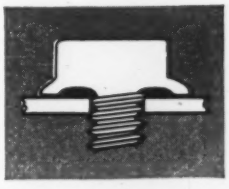
In operation at the General Electric Co. jet engine plant, the calculator is capable of giving a complete automatic simulated flight test on an aircraft. According to G-E engineers who designed the device, flight performance data can now be obtained about 30 times faster than with other systems previously in use.

Time required to put the data on computer cards and to make

(*Continued on Page 22*)



New Tuff-Tite* Fastener Is Leakproof—Holds Securely —Protects Surfaces



Neoprene washer trapped under head seals hole—acts as cushion.

Tuff-Tite is a new multi-purpose fastener that gives tight, leakproof seating without cracking or chipping porcelain enamel and other fine finishes. It also dampens vibration by acting as a shock absorber and eliminating squeaks and chatter.

All this is accomplished by Tuff-Tite's one-piece metal head and assembled neoprene washer. When tightened, the neoprene is trapped and controlled by an undercut in the washer head. **Trademark*

The neoprene is forced into the hole and around the threads to provide a cushion which protects the surface and forms a watertight and airtight seal.

Tuff-Tite fasteners are used for quick, secure, leakproof fastening of metals and plastics. They are available as tapping screws, thread cutting screws, drive screws, machine screws, stove bolts, wood screws and special fasteners. They are made of carbon, alloy and stainless steel, aluminum, brass and other metals in a variety of head styles.

To learn more about how Tuff-Tite can give you leakproof surface protection with economy, use the coupon below.

THE FASTENING AUTHORITY

Townsend

COMPANY • ESTABLISHED 1816

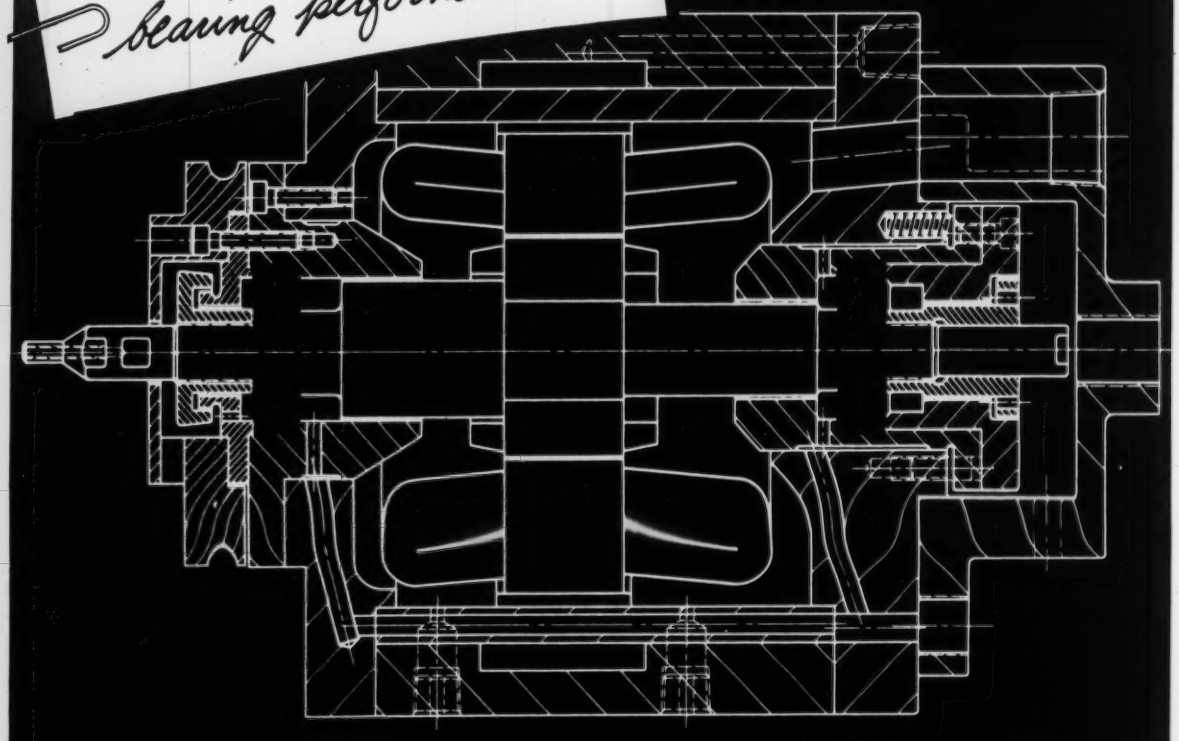
Sales Offices in Principal Cities

TOWNSEND COMPANY
Sales Department
New Brighton, Pa.

Please send to me without obligation "Tuff-Tite" Bulletin TL-97.

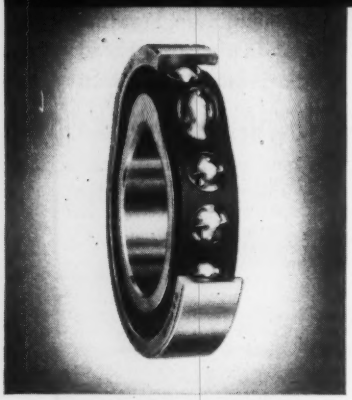
Name_____ Title_____
Company_____
Street_____
City_____ Zone_____ State_____

Looking for improved bearing performance?



over 14 billion revolutions...

– and still going strong



Fafnir Super-Precision MM201W1-CR spring-loaded ball bearing, the type specified for wheelhead illustrated.

Fafnir-equipped, high-speed, oscillating grinder wheelhead

demonstrates machine tool progress in performance

This extraordinary record has been made on the production line by a Pope-built wheelhead, grinding the races of extra-precision ball bearings. The hi-frequency motorized wheelhead operates at 72,000 rpm. The motor is water-cooled and bearings lubricated by means of an oil-air mist system.

When designing this oscillating grinder wheelhead, Fafnir engineers worked together with the Pope Machinery Company engineers in the selection and application of bearings. The type of bearing recommended is shown at the left and its application in the drawing above. Its performance record, according to Pope, demonstrates progress to match today's improved machine tools.

Whatever your bearing problem, a few minutes spent with a Fafnir representative may be the means of solving it as successfully. Write The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

—ITEM 163—

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Reader Information Service

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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JAN. 26, 1956

Circle item number for information on products advertised or described or copies of literature.

1	31	61	91	121	151	181	211	241	271	301	331	361	391	421	451	481
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14	44	74	104	134	164	194	224	254	284	314	344	374	404	434	464	494
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16	46	76	106	136	166	196	226	256	286	316	346	376	406	436	466	496
17	47	77	107	137	167	197	227	257	287	317	347	377	407	437	467	497
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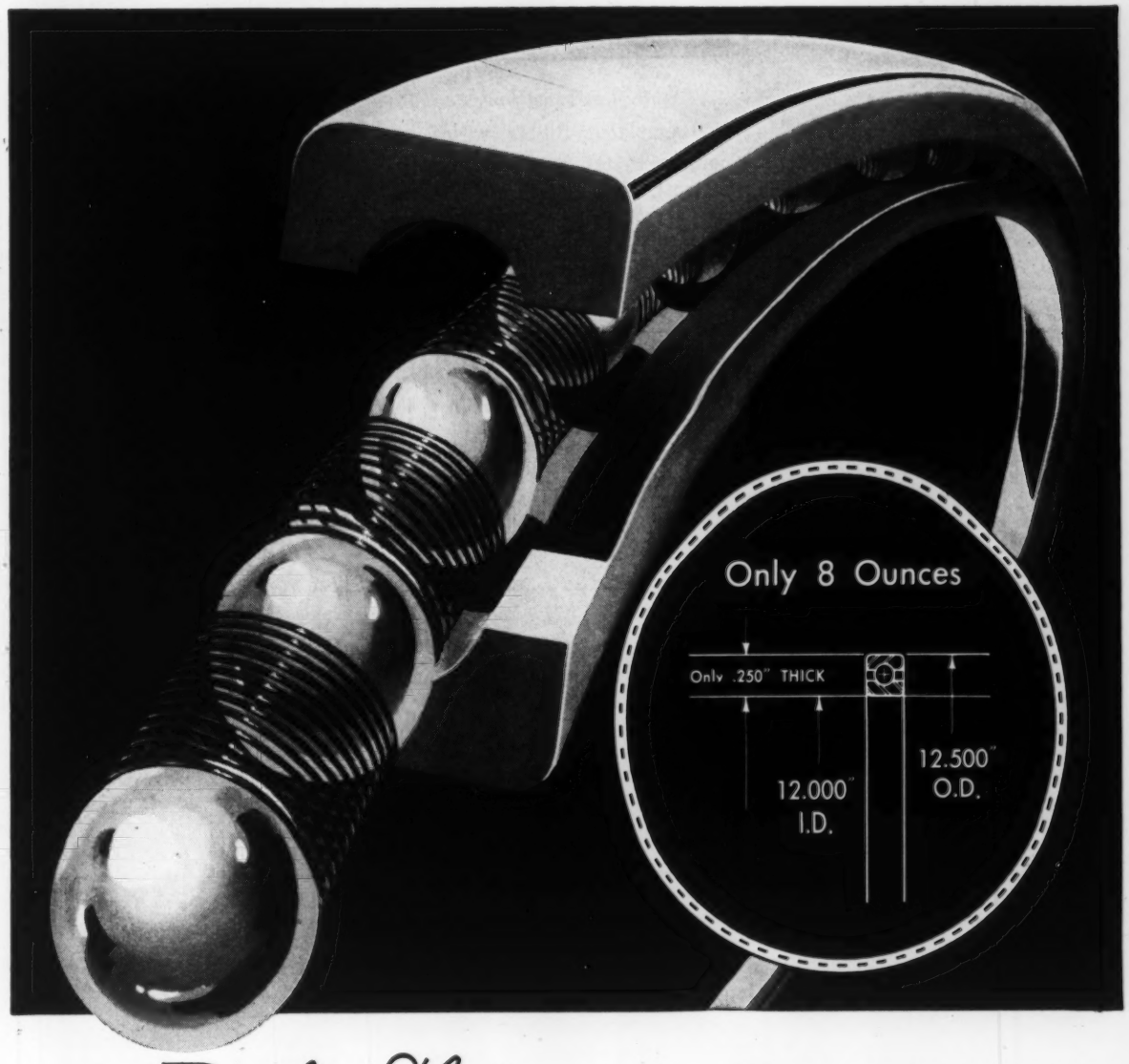


Reali-Slim... by Kaydon
world's thinnest radial ball bearing

HERE'S a typical example of Kaydon's *Reali-Slim* unique radial ball bearing that's finding wide application in practically every industry. *Reali-Slim* are the world's finest thin-section bearings and proportionately are thinner than a wedding ring. The bearing illustrated here is 12.000" I.D., 12.500" O.D., .250" thick — weighs less than 8 ounces. Designed for minimum weight and space limitations, it has a static load capacity of 5,520 lbs. and 894 lbs. at 100 rpm.

If you're looking for *Reali-Slim,* lightweight, radial ball or roller bearings, look at Kaydon's *Reali-Slim* line. Besides hundreds of standard *Reali-Slim* designs, there's a wide variety of special races, seals and separators to meet special bearing problems. What's more Kaydon is able to produce these *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual. In addition, Kaydon bearing engineers are prepared to give you valuable help with technical bearing application problems.

For complete data on *Reali-Slim* bearings for standard or special applications, ask for engineering Catalog No.54RS-2.

***Reali-Slim* Ball Bearings** — in Conrad, angular contact, 4-point contact and other types are available in seven standard cross sections from .250" to 1" and in bore diameters from 4" to 40".

***Reali-Slim* Roller Bearings** — in radial or taper roller types are available in cross sections from 3/16" and in bore diameters from 5" to 40".

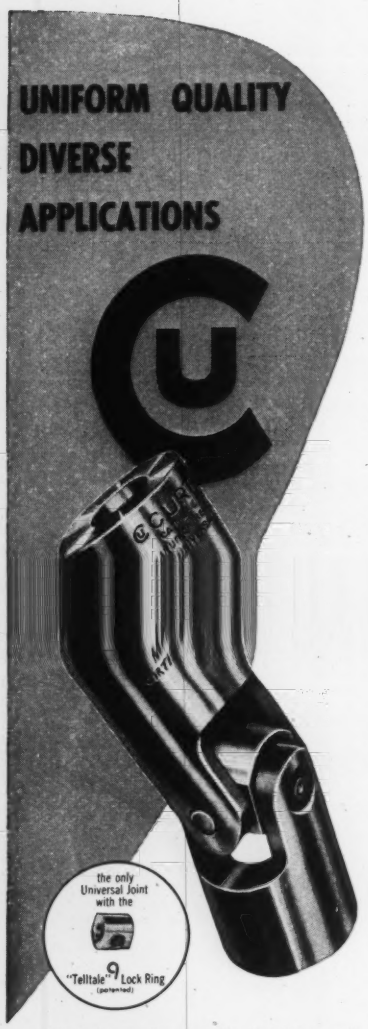
K-554

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" bore to 120" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Ball Radial • Ball Thrust Bearings

—ITEM 164—



Each part of every Curtis Universal Joint is made of specially selected steel, individually heat-treated for a specific purpose. This care in manufacture is reflected in our catalog torque and load ratings – which are substantiated by constant testing of production joints.

That's why Curtis Joints are the most dependable, durable and trouble-free available—the standard of the industry.

CURTIS UNIVERSAL JOINTS

- 14 sizes always in stock — bored or unbored hubs
- Fewer parts, simpler construction
- Complete equipment for government tests

PLUS — facilities and engineering skill to handle special specification jobs at any time.

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.

5 BIRNIE AVENUE, SPRINGFIELD, MASS.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

—ITEM 165—

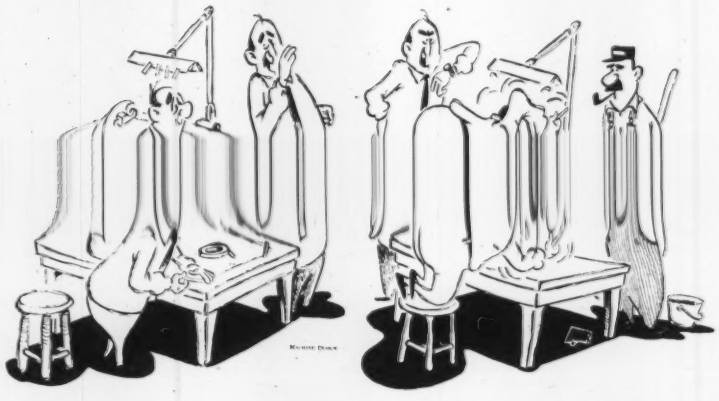
Engineering News Roundup

(*Continued from Page* 15)

the simulated flights varies according to the complexity of the aircraft. It may take three weeks to transfer engine and airframe data to the cards. At most, however, G-E engineers claim only a few hours are needed to get all the answers on a proposed airplane's performance.

Among the useful data obtainable from the machine are engine power requirements and fuel consumption at any speed and altitude.

It Never Fails . . .



"Thought I'd let you know that this is a long range program. So take your time."

"What are you trying to do, make a project out of this job?"

First overseas Caterpillar earthmoving machine came off assembly lines in Australia recently. The machine was built at Steelweld Pty. Ltd., Braybrook, Victoria.

Rubber vulcanizing without heat and without addition of sulphur has been performed by irradiating an experimental rubber with short gamma rays of cobalt 60 at Wright-Patterson Air Force Base, Dayton, O.

High-power silicon rectifiers capable of handling up to several kilowatts have been announced by Western Electric Corp. New diodes have a typical forward voltage drop of only 0.7-volt at a current of 8 amperes and at a cell temperature of 190 C.

Timken Roller Bearing Co. will spend a $5 million appropriation for production equipment and facilities to be installed in its plant at Columbus, O., according to L. D. Gable, Columbus general manager. Bearings for the railroad industry will be the products of the additional capacity.

Meetings

AND EXPOSITIONS

Feb. 17-18—

National Society of Professional Engineers. Annual Spring Meeting to be held at the Mayflower Hotel, Washington, D. C. Additional information may be obtained from society headquarters, 1121 Fifteenth St., Washington 5, D. C.

Feb. 19-23—

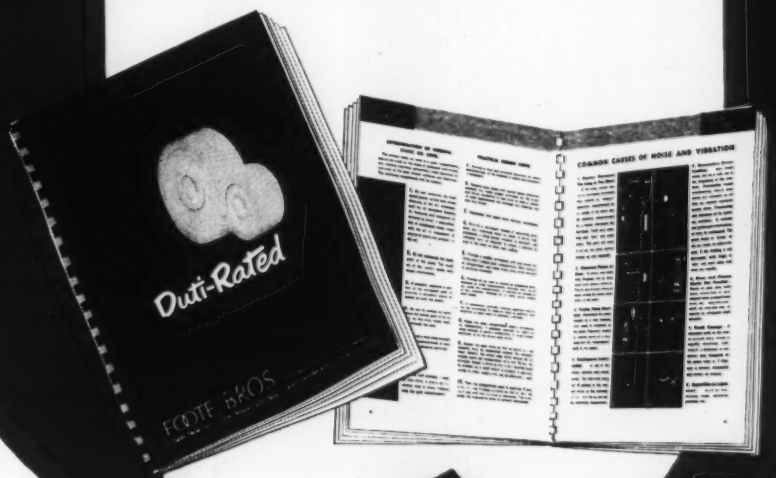
American Institute of Mining and Metallurgical Engineers. Annual Meeting to be held at hotels Statler and New Yorker, New York, N. Y. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Feb. 26-29—

American Institute of Chemical Engineers. Winter Meeting to be held at Hotel Statler, Los Angeles, Calif. F. J. Van Antwerpen, 120 E. 41st St., New York 17 is secy.

Q. How can you increase gear life and save space too?

A. With FOOTE BROS. Duti-Rated Gears.* New Engineering Manual DR shows complete standardized line designed to meet your power transmission needs.



*T.M. Reg. U.S. Pat. Off.

Write for your free copy today!

Some of today's toughest gear problems practically solve themselves with this new engineering manual. Small wonder, for it puts at your fingertips the full range of pre-engineered Duti-Rated Gear design data, specifications and selection tables. It's concise, yet complete . . . makes it easy to locate the gear set that will give you longer life and greater capacity in less gear space. It shows, too, how Duti-Rated Gears by Foote Bros. are the experience-proved way to maximum power transmission efficiency . . . oftentimes the most economical. Get your copy of Engineering Manual DR . . . now!

FOOTE BROS.

Better Power Transmission Through Better Gears

Since 1859

Foote Bros. Gear and Machine Corporation
4545 South Western Boulevard, Dept. O,
Chicago, Illinois

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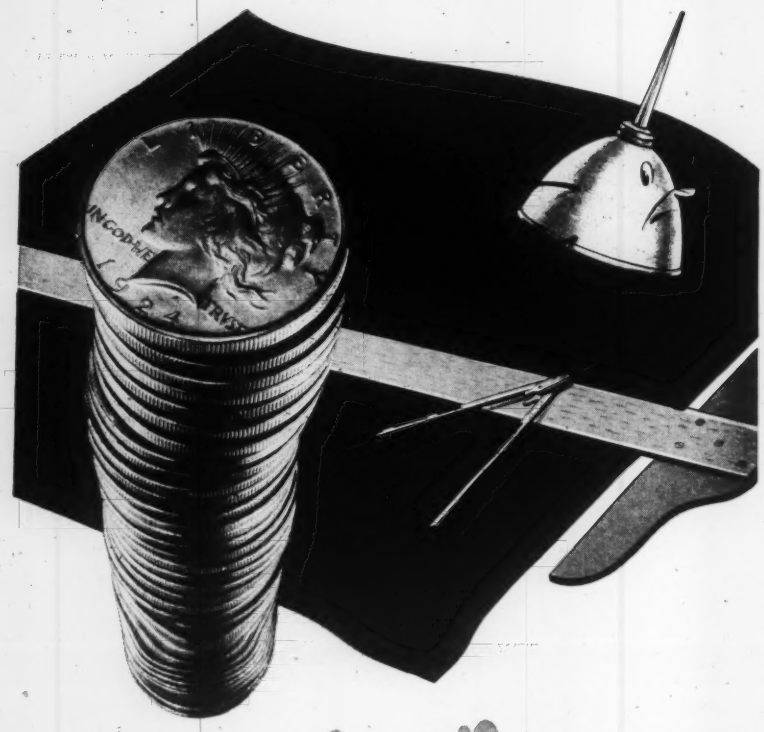


Profit Grows When The Oil Can Goes!

BIJUR

Automatic Lubrication

When you design a machine to include Bijur Automatic Lubrication as an integral component, the user profits many ways. Costly hand oiling is eliminated. Repair bills are substantially reduced. Productive capacity is increased because machines are lubricated while in operation; downtime is reduced. Every bearing receives the right quantity of oil at the right time. There are no starved or flooded bearings. In your customer's plant, safety is increased; fire risk is lessened; personnel injuries are avoided. All this adds up to greater sales appeal for your machines.

For more than a quarter of a century, machine manufacturers have looked to Bijur as the accepted standard of automatic lubrication. Well over a million Bijur Systems have already been installed. Let Bijur design a custom-engineered lubrication system for you, to fit machines now in production or in the planning stage.

Literature and engineering data are yours for the asking.

0-1

2369

BIJUR

LUBRICATING CORPORATION

Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

—ITEM 167—

News Roundup

Feb. 27-29—

American Management Association. Second Annual Electronics Conference & Exhibit to be held at Hotel Commodore, New York, N. Y. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 36, N. Y.

Feb. 27-March 2—

American Society for Testing Materials. National Meeting to be held at Hotel Statler, Buffalo, N. Y. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

March 6-8—

Society of Automotive Engineers. National Passenger Car, Body and Materials Meeting to be held at Hotel Statler, Detroit, Mich. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

March 8-9—

The Society of the Plastics Industry, Canada, Inc. Fourteenth Annual SPI Canadian Conference to be held at the Sheraton-Brock Hotel, Niagara Falls, Ontario, Canada. Additional information may be obtained from society headquarters, 67 West 44th St., New York 36, N. Y.

March 12-15—

National Electrical Manufacturers Association. Midwinter Meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 155 East 44th St., New York 17, N. Y.

March 12-16—

National Association of Corrosion Engineers. Twelfth Annual Conference and Corrosion Show to be held at Hotel Statler, New York, N. Y. A. B. Campbell, 1061 M & M Bldg., Houston 2, Texas, is executive secretary.

March 14-15—

American Society of Mechanical Engineers. Engineering Management Conference to be held at Hotel Statler, St. Louis, Mo. Addi-

tional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 14-16—

American Society of Mechanical Engineers. Aviation Division Conference to be held at Hotel Statler, Los Angeles, Calif. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 14-16—

Pressed Metal Institute. Annual Spring Technical Meeting to be held at the Carter Hotel, Cleveland, Ohio. H. A. Daschner, 3673 Lee Rd., Cleveland 20, Ohio, is managing director.

March 18-21—

American Society of Mechanical Engineers. Spring Meeting to be held at the Multnomah Hotel, Portland, Ore. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 19-20—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago, Ill. George K. Dreher, 606 Terminal Tower, Cleveland 13, O., is secretary.

March 19-21—

Society of Automotive Engineers. National Production Meeting and Forum to be held at Hotel Statler, Cleveland, O. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

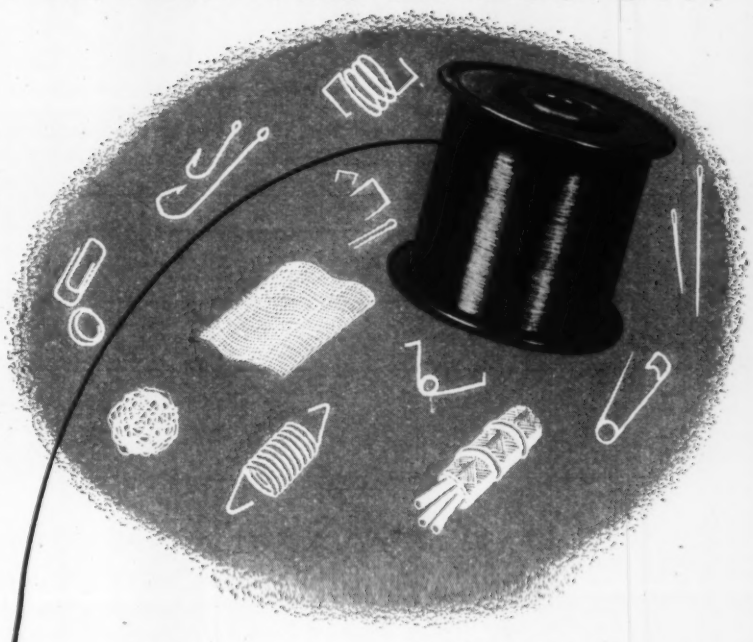
May 14-17—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 24-25—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

FOR FINE WIRE PRODUCTS . . .



Almet Stainless Steels

MEET MORE REQUIREMENTS
THAN OTHER ENGINEERING MATERIALS

Does your Fine Wire application call for resistance to heat? . . . to corrosion? Does it require good fatigue properties . . . excellent weaving or other forming characteristics? There's a good chance you will find the material you need among the more than 20 grades of stainless steel we fabricate into high quality Fine Wire. No other family of metals has the combination of properties common to the stainless steels.

Learn more about the interesting properties and applications of our stainless steel Fine Wire, as well as our stainless Rod and Strip . . . send today for a copy of our new 40 page Stainless Steel Design Handbook.

ALLOY METAL WIRE DIVISION

HKP
A DIVISION OF H. K. PORTER COMPANY, INC.

H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

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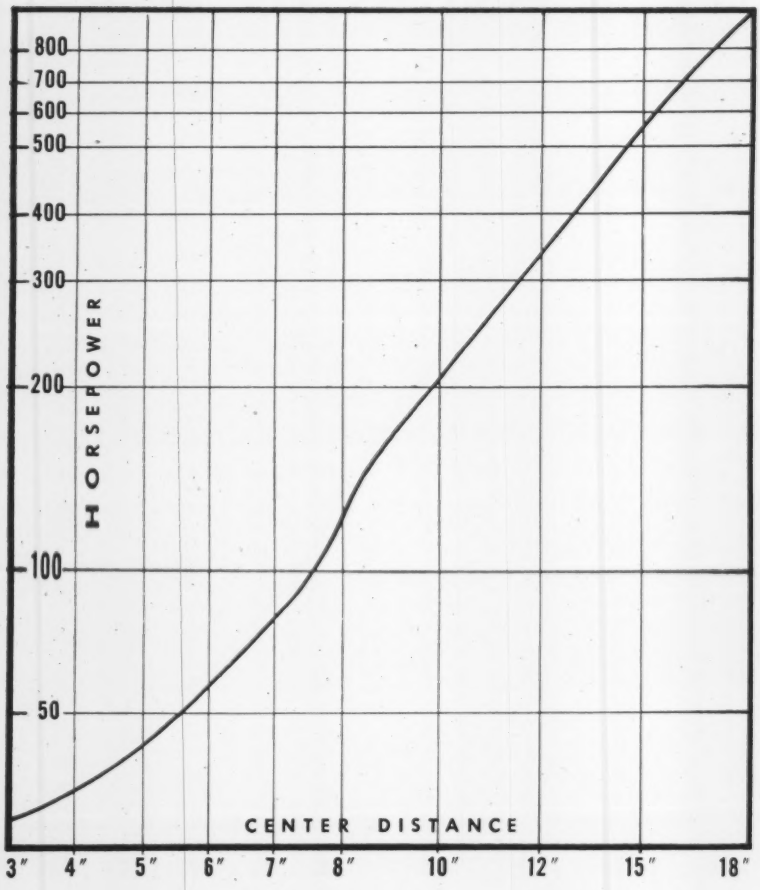
"DO-IT-YOURSELF"



Prove the difference in worm gear speed reducers yourself. Here's how . . .

. . . On this chart we've plotted the mechanical horsepower capacity of Cone-Drive worm gear speed reducers against their center distances. Ratings are for Class I Service with a 5:1 reduction and an input speed of 1750 rpm.

All you have to do is plot the corresponding ratings for the speed reducers you're now using or planning to use. We think you'll be surprised at the results.*

For details on Cone-Drive gearing's double-enveloping design and specifications, ask for Bulletin 600C. We'll send it to you immediately without obligation.

*If you're too busy to "Do-it-yourself", Cone-Drive representatives will be glad to show you filled-in charts.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

—ITEM 169—
For More Information Circle Item Number on Yellow Card—page 19

MEN

OF MACHINES

Caterpillar Tractor Co., Peoria, Ill., has appointed **Frank A. Grooss** assistant to vice president **G. E. Burks,** who is in charge of administration for the engineering and research departments. Mr. Grooss was formerly assistant chief engineer at the company's Decatur, Ill. plant. He joined Caterpillar in

Frank A. Grooss

1941 and entered the engineering department in 1948. He was appointed assistant chief engineer at Decatur in December, 1954, and is succeeded in that position by **A. W. Sieving,** formerly general supervisor of engineering at Decatur.

Zeke R. Smith has been appointed chief engineer of applications by Potter & Brumfield, Princeton, Ind.

The board of directors of Crucible Steel Co. of America, Pittsburgh, has elected **Maurice J. Day** vice president of research and development. He previously was director of research and development.

Edward J. Lunney has been named chief engineer in charge of

the research and analysis department of Barry Controls Inc., Watertown, Mass. Since 1940 Mr. Lunney has been associated with the Wright Air Development Center of the U. S. Air Force and prior to that time was an engineer with Heald Machine Co.

John T. Burwell Jr. has been named vice president by Horizons Inc., Cleveland. Dr. Burwell has served as associate director of research since joining the organization in 1951.

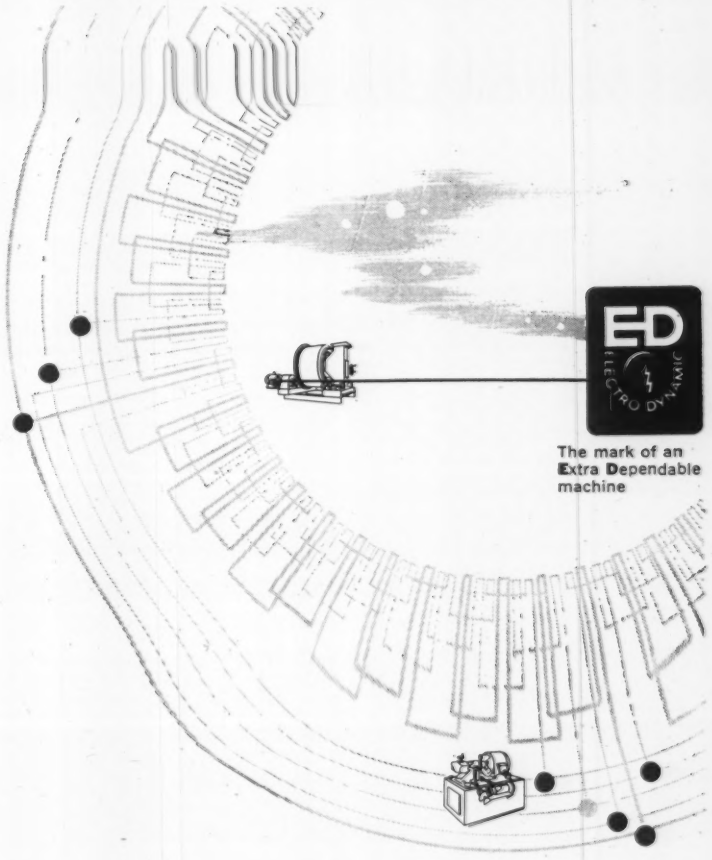
Soreng Products Corp., Schiller Park, Ill., has appointed **Frederick Morawetz** manager of research and development in its central engineering division. Mr. Morawetz was formerly associated with National Presto Industries Inc., Schick Inc. and Federal Telephone and Radio Corp.

Morris L. Hutchens has been named chief engineer of Kearney & Trecker Corp., Milwaukee. He

Morris L. Hutchens

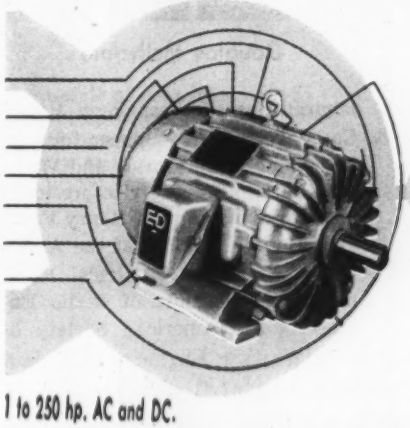
succeeds **Orrin W. Barker,** who recently was named vice president in charge of engineering. Mr. Hutchens has been chief engineer of special machinery since 1952.

Fairchild Camera and Instrument Corp., Syosset, N. Y., has established a Nuclear Instrumentation Dept., headed by **Harold Eugene DeBolt.** Dr. DeBolt comes to Fairchild from the Nuclear Power Div. of the Navy's Bureau of Ships



The mark of an Extra Dependable machine

a better kind of power
FOR INDUSTRIAL MACHINES



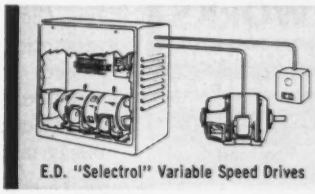
1 to 250 hp. AC and DC.
N.E.M.A. standards.

Extra starting and anti-stalling capacity: Extra cool, extra quiet operation: Achieved without sacrifice of full-load efficiency. Backed by unparalleled experience, E.D. motors are *extra dependable*—75 years in the making—yours today *at no extra cost!*

ELECTRO Extra DYNAMIC Dependable motors
PRODUCT OF GENERAL DYNAMICS

NEW...
Write for Brochure 100 and literature on new E.D. motors and drives.

Electro Dynamic division of General Dynamics Corporation
Bayonne, New Jersey

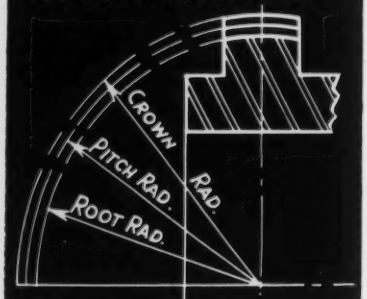


E.D. "Selectrol" Variable Speed Drives

New Re-rated E.D. Motors

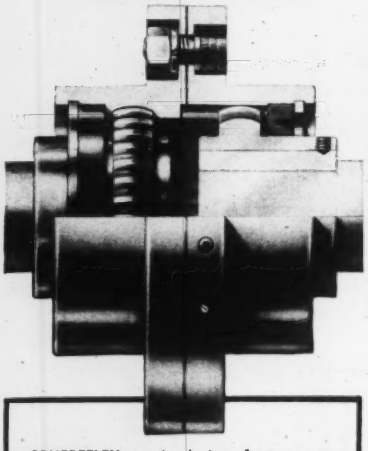
Gear-ED-motors

—ITEM 170—

Here's the Big DIFFERENCE
TEETH ARE CUT


ON A TRUE ARC

SPHEREFLEX®
COUPLING



SPHEREFLEX tooth design features an exclusive curved root and spherical tooth flank. Both angular and linear (parallel) misalignment are compensated for, since every portion of each gear tooth is actually a segment of a sphere. This special design eliminates all possibility of tooth interference and permits increased deflection between mating members. Full and uniform line contact, through the working depth of the tooth, insures a stronger coupling between driver and driven shafts; eliminates point rolling contact between gears during flexing; compensates for shaft misalignment up to 14° included angle. Send for Catalog C-560

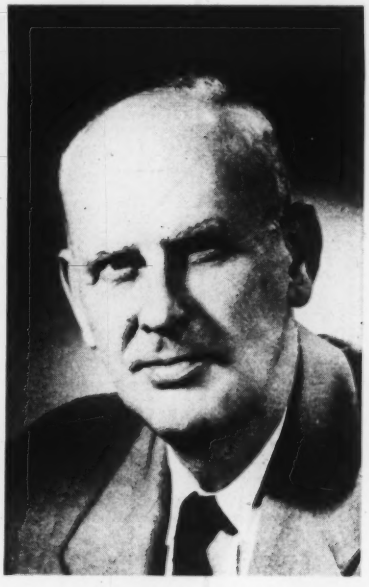
PHILADELPHIA GEAR WORKS
INCORPORATED
ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA.
BALTIMORE • CLEVELAND
Virginia Gear & Machine Corp., Lynchburg, Va.
Industrial Gears & Speed Reducers • LimiTorque Valve Controls
Established 1892

—ITEM 171—

Men of Machines

and the Naval Reactor Branch of the Reactor Development Div. of the Atomic Energy Commission.

Douglas McIlvaine has been appointed to the newly created post of director of research and development by Acro Mfg. Co., Columbus, O. Mr. McIlvaine was formerly manager of research and development for Soreng Products Corp. and also has served as manager of the meter department and test



Douglas McIlvaine

laboratories of West Penn Power Co., development engineer for Bell Telephone Laboratories and Western Electric Co. and vice president and works manager of Henry Valve Co. He is a member of the American Institute of Electrical Engineers, the Instiute of Radio Engineers, the American Society of Refrigerating Engineers, and is a registered professional engineer.

Alloy Precision Castings Co., Cleveland, recently announced the appointment of **C. B. Beener** as chief engineer.

Reorganization of the engineering department of Jack & Heintz Inc., Cleveland, has resulted in the promotion of **Omar C. Walley** and **Robert G. Dobbin** to head development work in two major divisions of the company. Mr. Walley, formerly manager of the controls and systems section, is now chief pro-

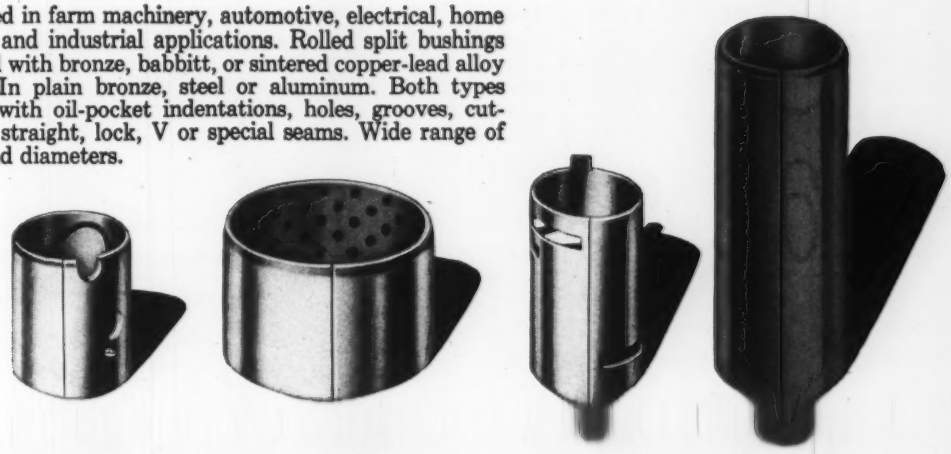
Omar C. Walley

ject engineer in charge of all engineering sections developing alternating-current electric systems. Mr. Dobbin, formerly manager of commercial products design, has been named chief project engineer responsible for engineering sections developing direct-current generators, actuators, engine starters, inverters and aircraft and commercial motors. Mr. Walley has had more than 15 years of experience in the development of apparatus for aircraft electric systems; Mr. Dobbin has had over 10 years of experience in electric component design. An article written by Mr. Dobbin, "When to Specify Special Motors," appeared in the November 1955 issue of MACHINE DESIGN.

Robert G. Dobbin

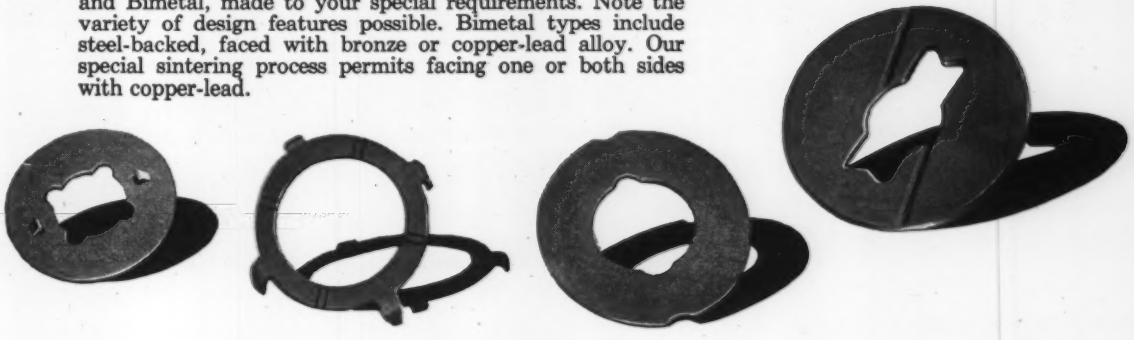
BUSHINGS

widely used in farm machinery, automotive, electrical, home appliance and industrial applications. Rolled split bushings in Bimetal with bronze, babbitt, or sintered copper-lead alloy on steel. In plain bronze, steel or aluminum. Both types available with oil-pocket indentations, holes, grooves, cut-outs, and straight, lock, V or special seams. Wide range of lengths and diameters.



WASHERS

for automatic transmissions and similar applications. In bronze and Bimetal, made to your special requirements. Note the variety of design features possible. Bimetal types include steel-backed, faced with bronze or copper-lead alloy. Our special sintering process permits facing one or both sides with copper-lead.



SPACER TUBES

sleeves, bushings or ferrules. Thousands of uses from cars to phonographs. Rolled split type in steel, from ¼″ to 3″ O.D. Economical replacement for tubing or machined parts. No cut-off, de-burring or scrap. Ready to assemble. Send for catalog of 645 standard sizes and prices.

Here are exceptional facilities and equipment for low-cost quantity production of your requirements. Complete engineering service.

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

FEDERAL-MOGUL

DIVISION

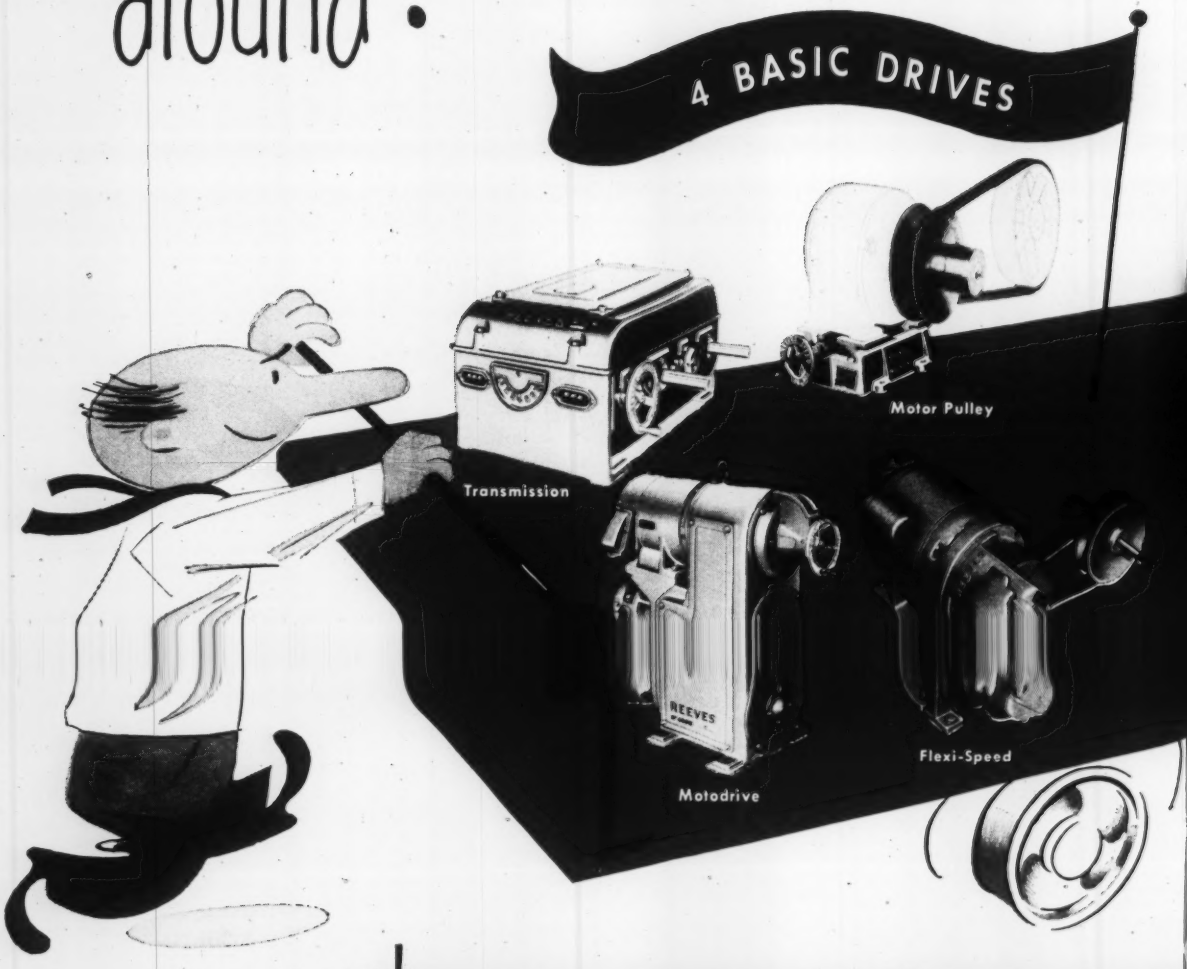
FEDERAL Mogul

SINCE 1899

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICH.

—ITEM 172—

Why shop around? REEVES



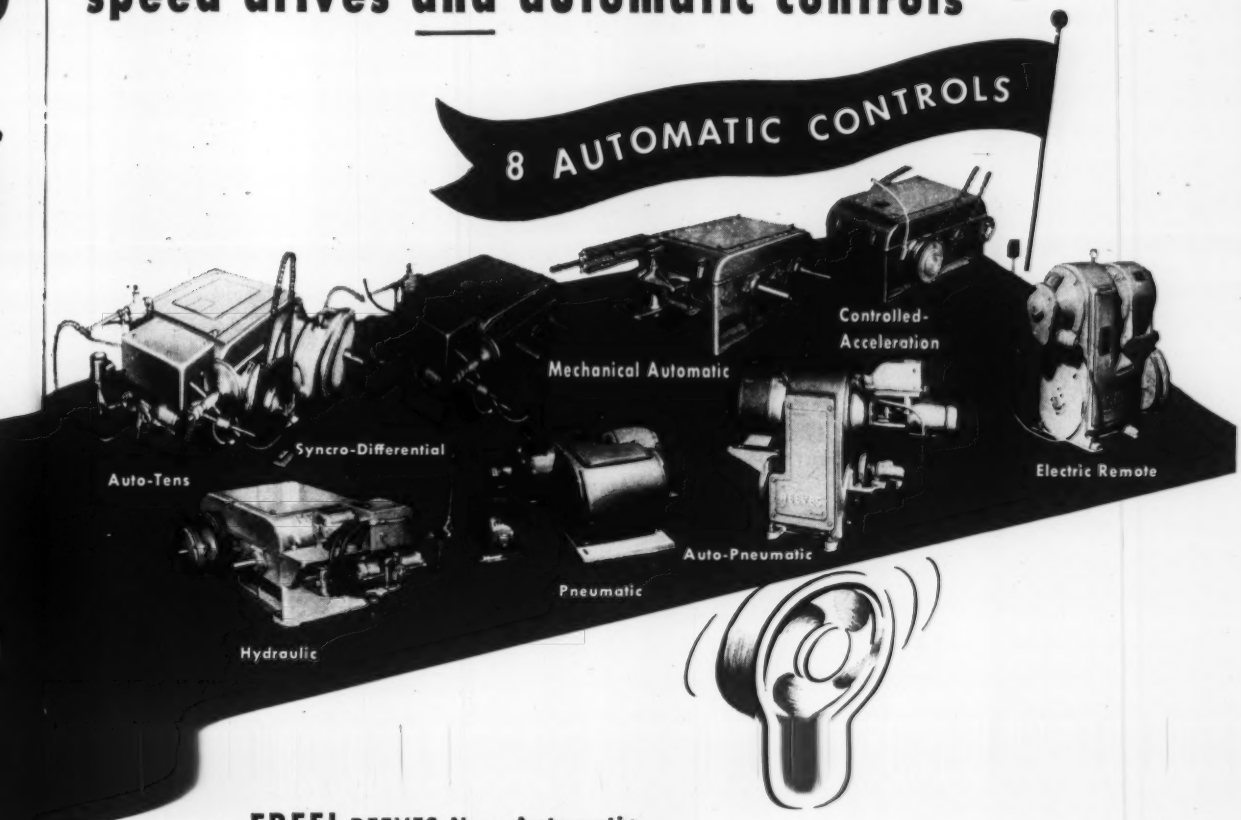
REEVES

Recognized Leader in the specialized field of variable speed control

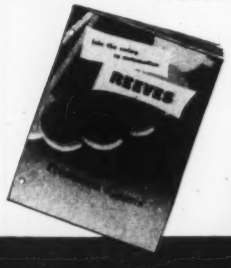
REEVES FLEXI-SPEED . . . with new low speeds!

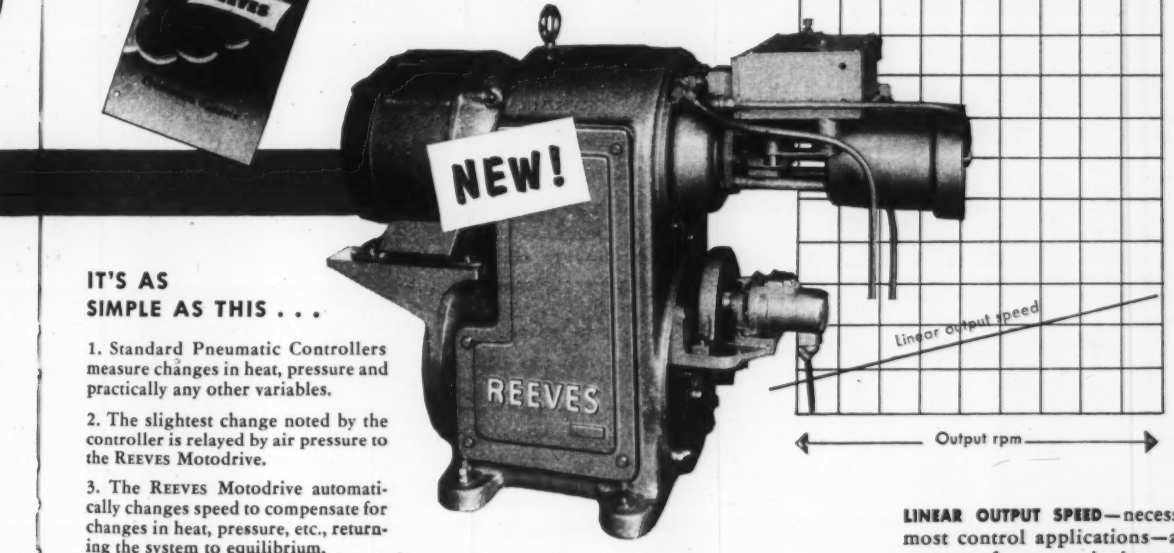
Amazing *new* Flexi-Speed is but one outstanding example of the complete line of REEVES Variable Speed Drives. Now available with output speeds from 300 rpm to 4800 rpm—speed ratios as great as 8:1. Combines efficiency, versatility and *low price.*

offers the only complete line of variable speed drives and automatic controls



FREE! REEVES *New* Automatic Production Control Booklet — Specify H4b-G537.





IT'S AS SIMPLE AS THIS . . .

1. Standard Pneumatic Controllers measure changes in heat, pressure and practically any other variables.

2. The slightest change noted by the controller is relayed by air pressure to the REEVES Motodrive.

3. The REEVES Motodrive automatically changes speed to compensate for changes in heat, pressure, etc., returning the system to equilibrium.

LINEAR OUTPUT SPEED—necessary to most control applications—assures exactness for proportioning and gives precise speed control *throughout the entire range* of the Motodrive.

REEVES AUTO-PNEUMATIC CONTROL

for regulating flow, pressure, heat, etc.

REEVES PULLEY COMPANY • COLUMBUS, INDIANA

—ITEM 173—

REPRINTS AVAILABLE FROM MACHINE DESIGN

Multiple-Circuit Switches

lever – rotary – push or pull

by Keith A. Carlson
Associate Editor, MACHINE DESIGN

A design manual on the factors to be considered in the selection and application of multiple-circuit switches.

Part One—discusses physical and electrical characteristics of lever-operated switches

Part Two—discusses physical and electrical characteristics of rotary switches

Part Three—discusses physical and electrical characteristics of push or pull switches

Part Four—discusses factors to be considered when selecting switches from these types for a specific application

How to select and apply

Electrical Connectors

by Laurence D. Shergalis
Assistant Editor, MACHINE DESIGN

Separable electrical connectors can often help satisfy several design objectives—convenience, portability or mobility, flexibility. Connectors provide these features in two kinds of circuits—power and signal.

Part One—discusses how to select and apply Electrical Connectors for power circuits

Part Two—discusses how to select and apply Electrical Connectors for signal circuits

Order your copies today

MACHINE DESIGN
READER SERVICE
Penton Building
Cleveland 13, Ohio

SEND ME____ copies of "MULTIPLE CIRCUIT SWITCHES" at $1.00 per copy

____ copies of "ELECTRICAL CONNECTORS" at $1.00 per copy

NAME_____

TITLE_____

COMPANY_____

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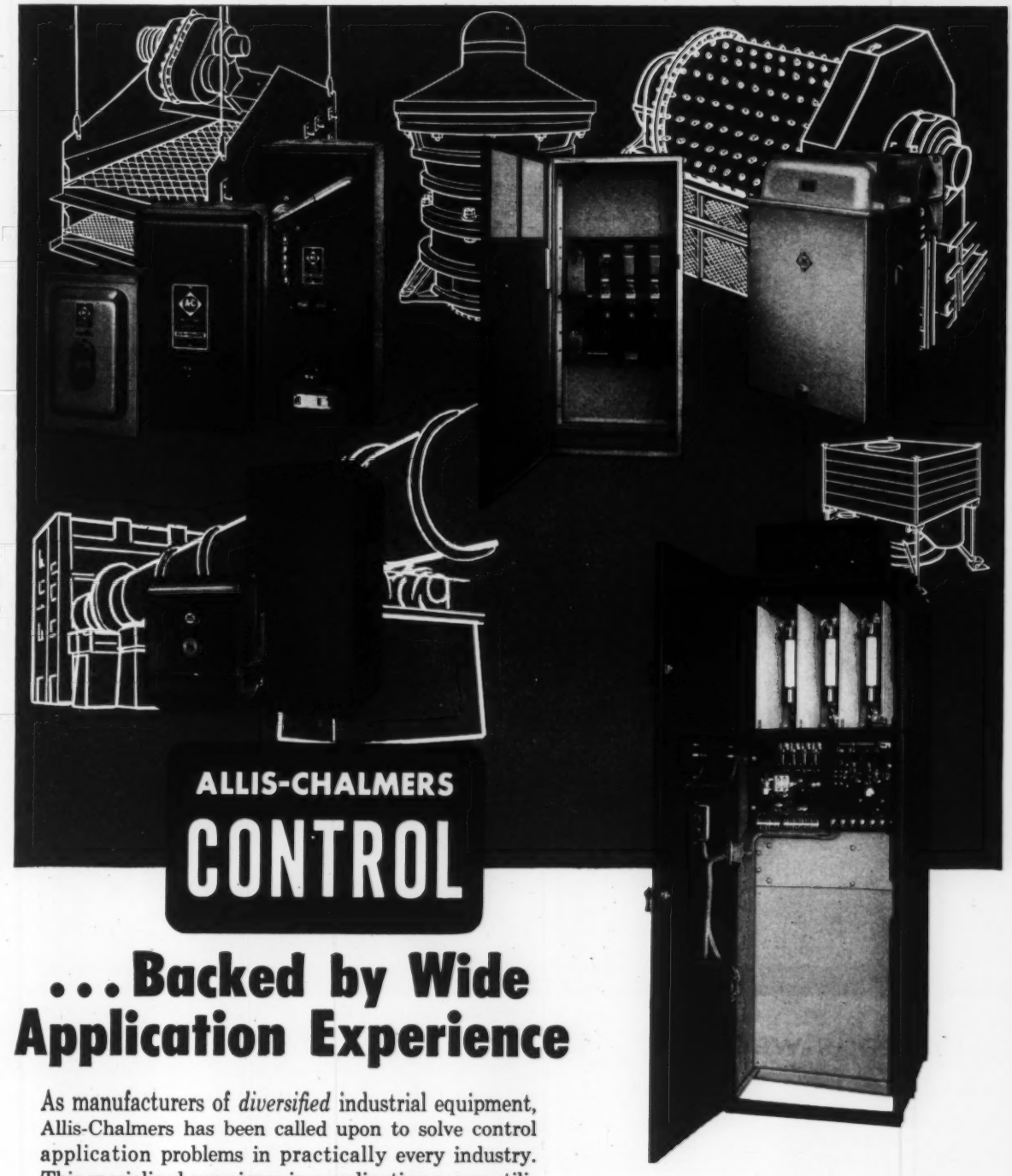
CITY_____ ZONE____ STATE_____

☐ Remittance enclosed

☐ Please bill me

(Add 3% to orders for delivery in Ohio to cover state sales tax)



ALLIS-CHALMERS

CONTROL

. . . Backed by Wide Application Experience

As manufacturers of *diversified* industrial equipment, Allis-Chalmers has been called upon to solve control application problems in practically every industry. This specialized experience in coordinating power utilization is yours when you specify Allis-Chalmers control.

The Allis-Chalmers line includes control for every condition of motor operation. Functions include full or reduced-voltage starting, acceleration, speed control, reversing or non-reversing, and dynamic braking. Built into Allis-Chalmers control is the type and degree of protection dictated by the application. Controls are available in general-purpose and special enclosures.

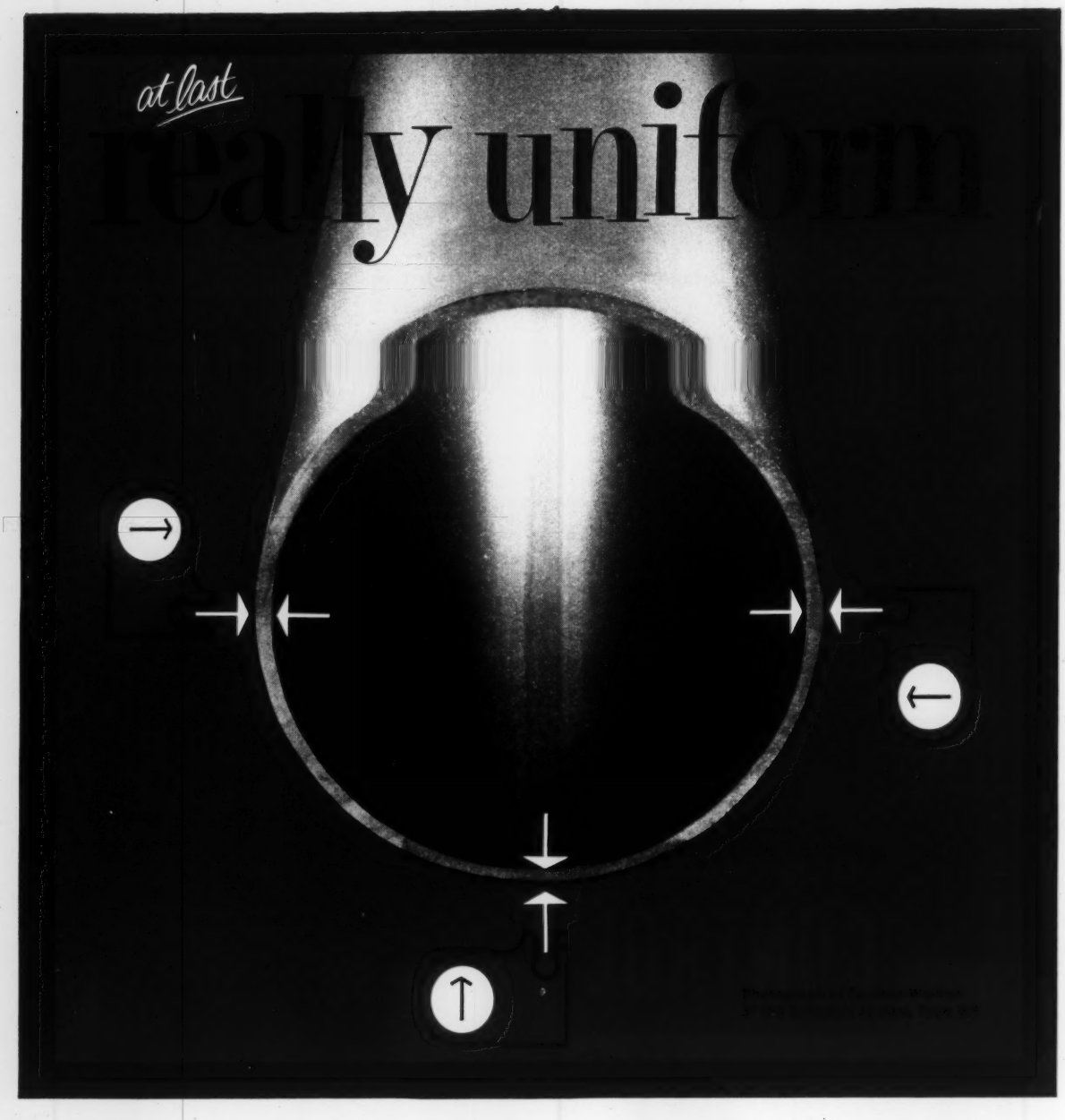
A-4587

For help on a specific control application, call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers engineering departments . . . by experience gained in solving thousands of control problems . . . by complete research and testing facilities.

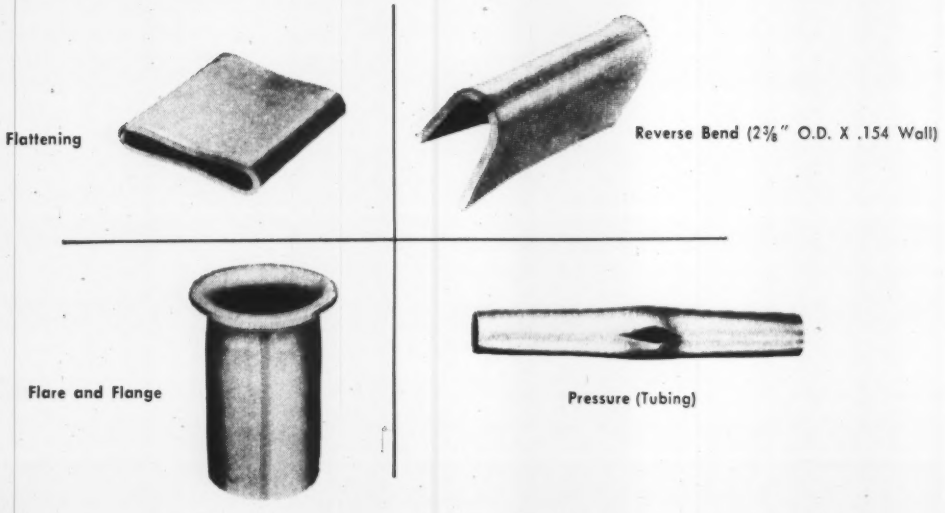
ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN

—ITEM 174—



CONTOUR-WELD PIPE... BEST BY ANY TEST YOU CAN NAME



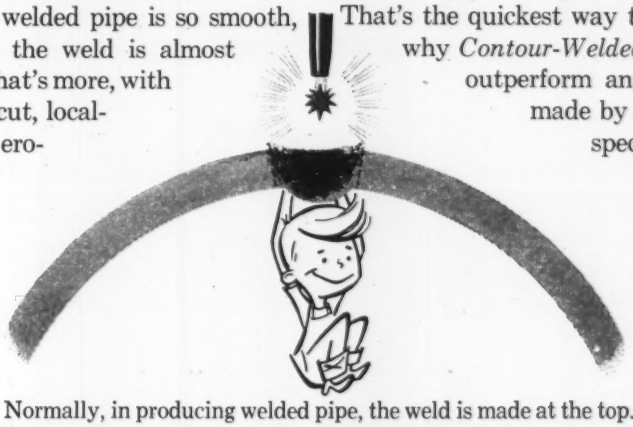
stainless pipe

...by Trent's new Contour-Weld process

Trent's new, patented *Contour-Welded*® stainless pipe and tubing gives you all the uniformity of wall thickness you'd expect in welded pipe and tubing – plus equal uniformity in the weld zone itself.

This new-type welded pipe is so smooth, so uniform, that the weld is almost imperceptible. What's more, with no bead or undercut, localized corrosion or erosion is eliminated . . . physical properties are better than those of any other pipe, welded or not.

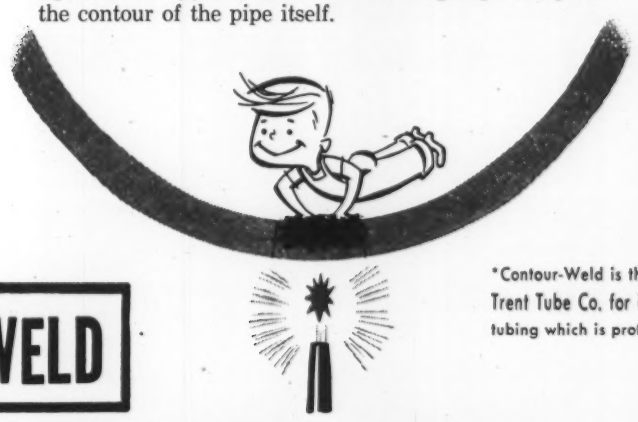
But try Trent's new *Contour-Welded* pipe or tubing yourself. As a matter of fact, ask for a sample – and give it any test you like. That's the quickest way to see for yourself why *Contour-Welded* pipe and tubing outperform any other. And it's made by Trent – tube mill specialists.



Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most—right on the I.D. surface. If you try to get rid of the bulge—at fair cost—the metal is undercut—and corrosion and erosion start there.

Why Trent's Exclusive *Contour-Weld* Process Means Smoother Welds . . .

But Trent put a stop to that—simply by going into partnership with gravity. With their exclusive *Contour-Welding* process, they weld at the bottom—and gravity works for them. For then, the bulge is in the opposite direction—blending in perfectly with the contour of the pipe itself.



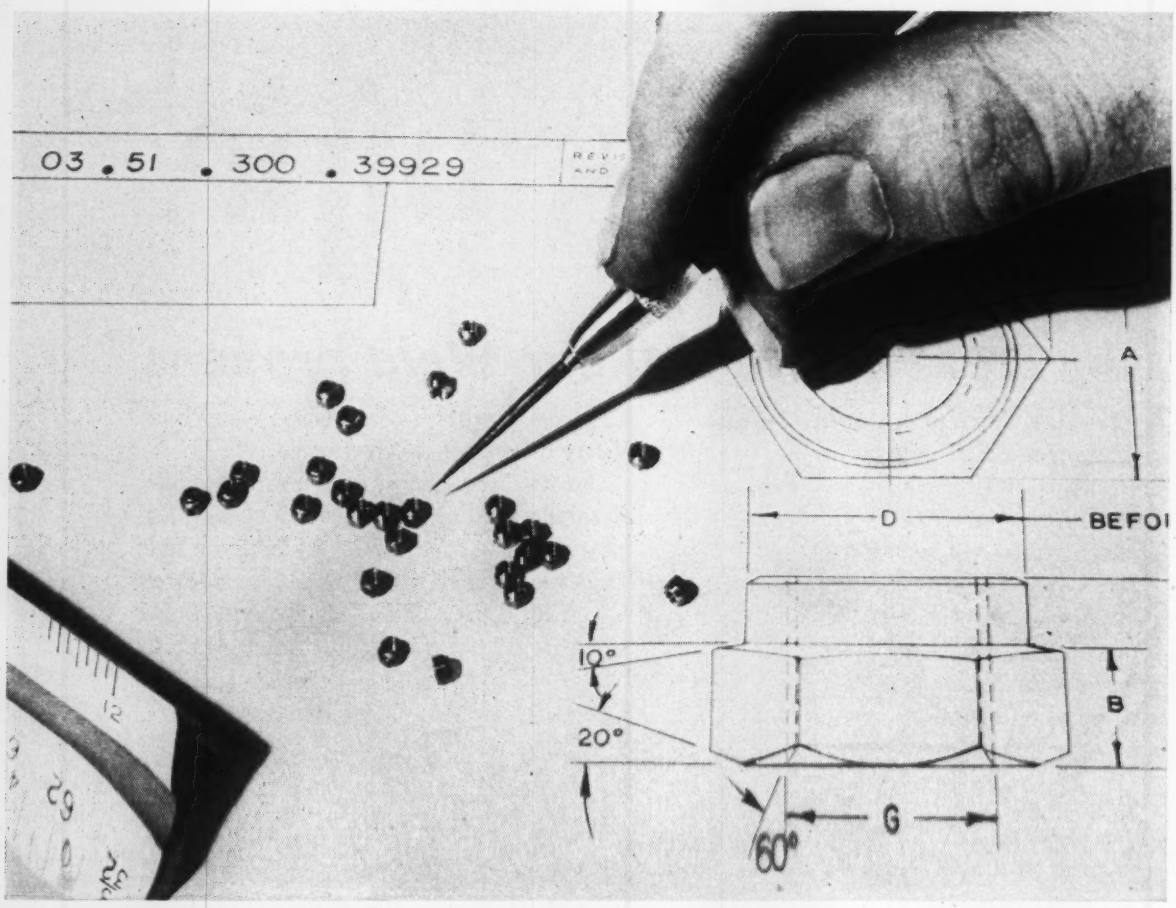
TRENTWELD

STAINLESS STEEL TUBING

*Contour-Weld is the trade mark of the Trent Tube Co. for its process of welding pipe and tubing which is protected under U.S. Patent 2,716,692.

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)

—ITEM 175—



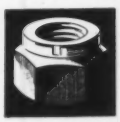
FLEXLOC Micro locknuts meet designers' needs for tiny precision nuts that retain strength and holding power in the smallest assemblies—servomechanisms, electronic and electrical equipment, all miniature devices.

Design Lighter, More Compact Products with New FLEXLOC Micro Nuts

Standard Miniature Locknuts Permit Design Engineers to Develop and Fasten Smaller Assemblies Safely

SIZE	Across Flats		Shoulder Height		Across Corners	Height +.000 −.003
	MAX.	MIN.	MAX.	MIN.	MIN.	
0-80 NF-3B	.111	.107	.047	.042	.123	.075
1-64 NC-3B	.127	.123	.0635	.0585	.141	.090
1-72 NF-3B	.127	.123	.0635	.0585	.141	.090
2-56 NC-3B	.158	.153	.068	.063	.176	.105
2-64 NF-3B	.158	.153	.068	.063	.176	.105
3-48 NC-3B	.190	.183	.071	.066	.210	.120
3-56 NF-3B	.190	.183	.071	.066	.210	.120
4-40 NC-3B	.190	.183	.072	.067	.210	.120
4-48 NF-3B	.190	.183	.072	.067	.210	.120

STANDARD FLEXLOC Micros—in sizes ranging from 0-80 to 4-48—are available in brass (either plain or cadmium plated). Consult SPS for miniature nuts of other conventional materials.



New FLEXLOC Micro locknuts are smaller and lighter than regular FLEXLOCS of the same nominal diameter. Wrenches of smaller size are used to install them. Mating joints or flanges can be designed smaller—with no loss in strength or convenience of assembly.

FLEXLOC Micros have all the advantages of larger FLEXLOCS. One-piece, all-metal construction—nothing to put together, come apart, lose or forget. Use them as lock or stop nuts—they stay put anywhere on a threaded member as soon as the locking threads are fully engaged. Uniform locking torques insure accurate preloading. There are no nonmetallic inserts to pop out or deteriorate. Moisture, dryness, oil, temperatures to 250°F won't affect these Micro nuts. Just screw them on. They lock and stay locked. Vibration won't shake them loose.

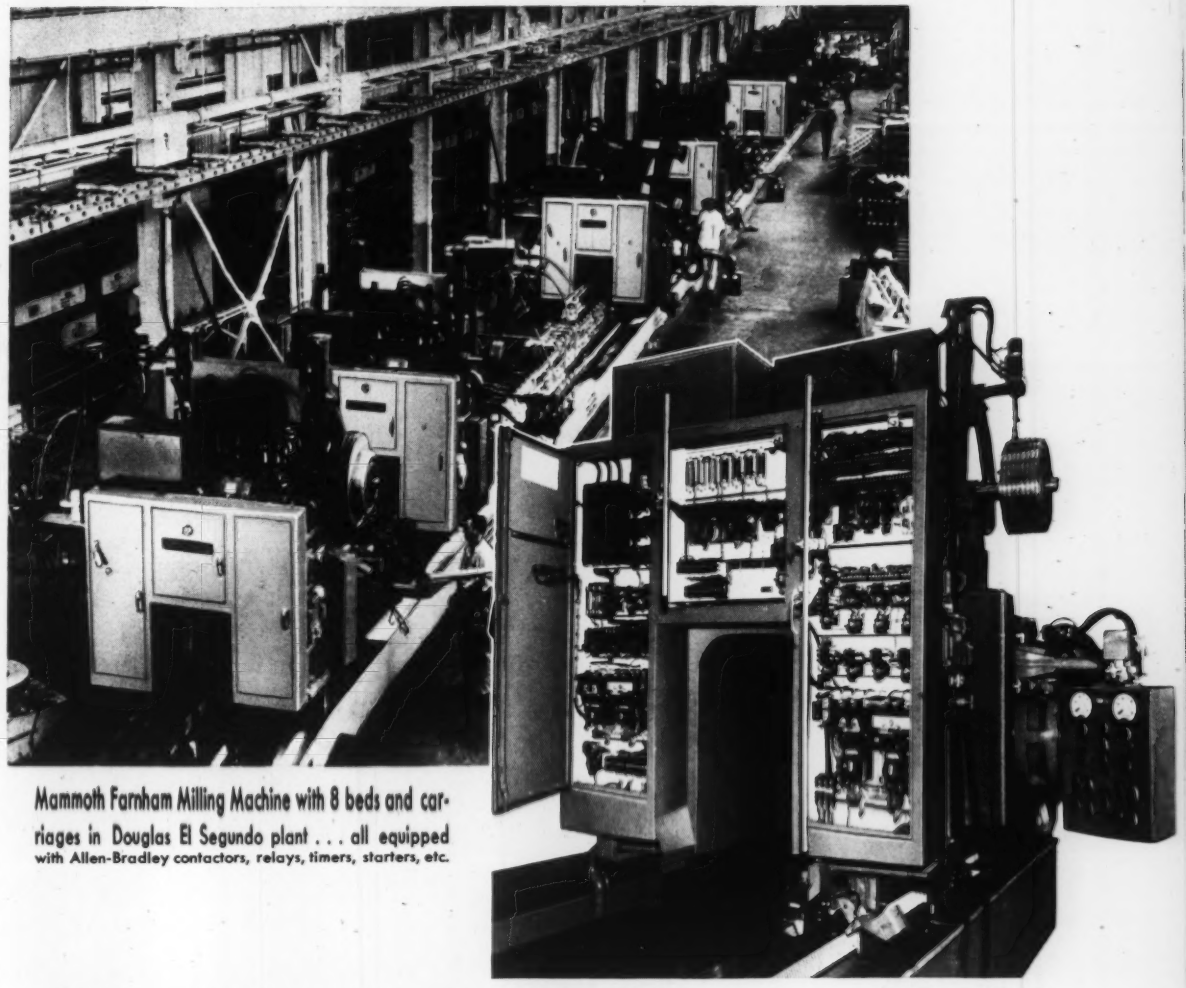
For complete information on FLEXLOC Micro locknuts, consult your authorized SPS distributor. Or write STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC® LOCKNUT DIVISION SPS

JENKINTOWN PENNSYLVANIA

—ITEM 176—

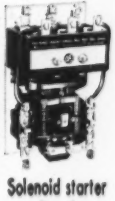


Mammoth Farnham Milling Machine with 8 beds and carriages in Douglas El Segundo plant . . . all equipped with Allen-Bradley contactors, relays, timers, starters, etc.

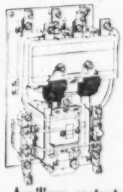
308 FOOT MILLING MACHINE

. . . operated by Allen-Bradley Motor Controls

Solenoid starter Size 1



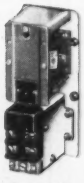
Solenoid starter Size 3



Auxiliary contacts on starter hood

Oiltight potentiometer control

Pendent push button control



Pneumatic automatic timer

Universal 4-pole relay

Oiltight push button, NO & NC contacts

Interlocking terminal blocks

Oiltight limit switch—all types

When the Farnham Manufacturing Division of The Wiesner-Rapp Co., of Buffalo, N.Y. built this impressive, 308 foot milling machine, they used Allen-Bradley control components for all 8 carriages. Thus, they assured themselves and Douglas of utmost reliability for this complex machine tool.

If you manufacture motor-driven machines, don't overlook the fact that Allen-Bradley motor controls are a big sales asset to any machine. The A-B trademark is a guarantee of trouble free performance . . . and is so recognized by machine tool buyers. Did you notice how much in evidence this trademark was at the Chicago Machine Tool Show?

Send for the Allen-Bradley Handy Catalog. It is a valuable handbook on modern motor control. Write today.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

A-B Quality

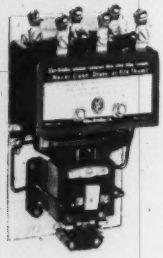
ALLEN-BRADLEY QUALITY

SPECIAL PANELS

ALLEN-BRADLEY
A-C CONTACTORS

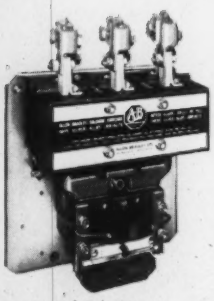
2 pole—Size 00
10 ampere

3 pole—Size 1
25 ampere

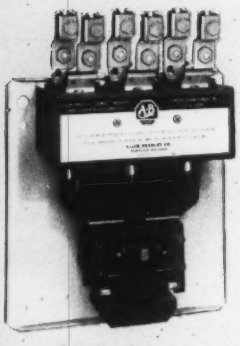


3 pole—Size 2
50 ampere

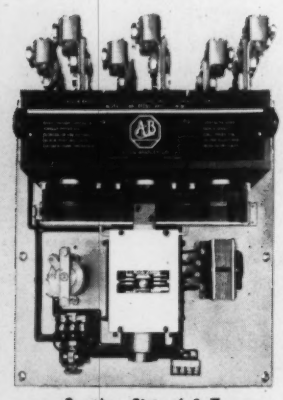
3 pole—Size 3
100 ampere



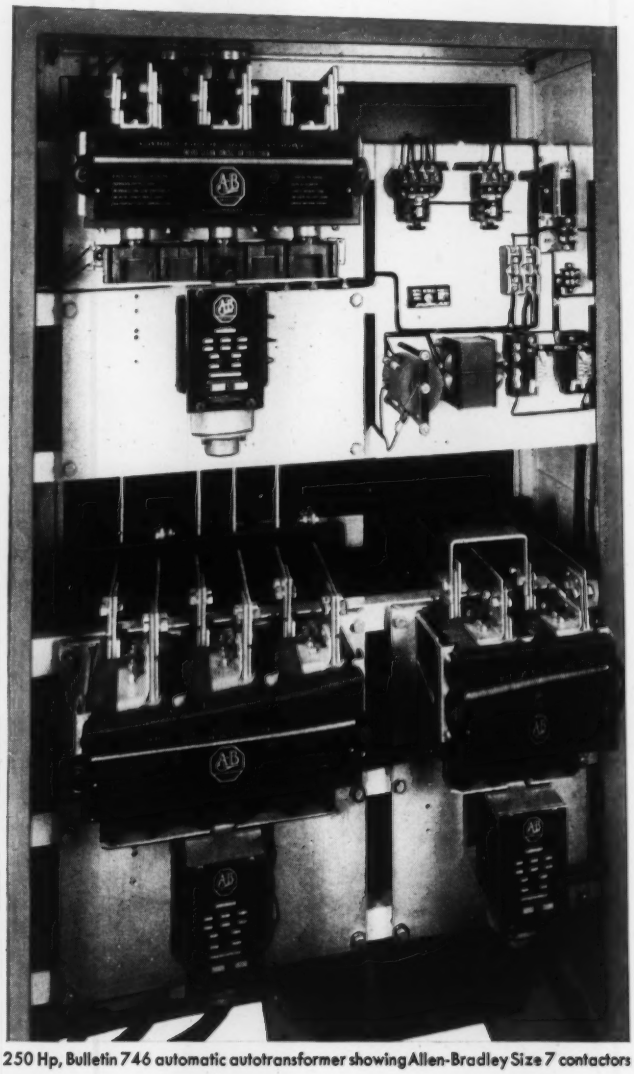
3 pole—Size 4
150 ampere



3 pole—Size 5
300 ampere



3 pole—Sizes 6 & 7
600 & 900 ampere contactors



250 Hp, Bulletin 746 automatic autotransformer showing Allen-Bradley Size 7 contactors

A-C and D-C CONTACTORS

10 to 900 Amperes

with Double Break, Silver Alloy Contacts

The only complete line of solenoid contactors on the market. Allen-Bradley offers nine sizes...from Size 00 (10 amperes) to Size 7 (900 amperes), one to four poles.

There is no contact maintenance . . . no pins, pivots, or bearings to give trouble. Just one moving part—the simple solenoid plunger. Operating characteristics are consistent for all nine sizes.

Enclosures can be supplied for general purpose, water-tight, dust-tight, and explosion-proof service.

Allen-Bradley controls are an added sales asset to any machine. May we send you our catalog?

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

A-B Quality

ALLEN-BRADLEY
SOLENOID CONTACTORS
QUALITY

✓ happy balance between dependable performance and moderate cost

Tru-Rol *precision, steel-cage, heavy-duty bearing with contoured guide lips assuring true right-line rolling, maintained roller alignment and thin oil film.*

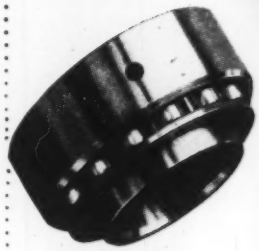
● Rollway's *TRU-ROL* Steel-Cage Bearings afford wide latitude in balancing *dependable* performance, *long* life, and *high load* capacity against *moderate* cost. They rate high in any comparison on a cost-performance basis.

A choice of stamped steel retainers with contoured guide lips, or steel segmented retainers assure true rolling and an evenly distributed *thin* oil film — *big factors in reducing power losses and heating.*

"Crowned" Rollers Relieve End Stress

TRU-ROL offers the extra advantage of a finish-ground "crown" radius on the roller ends. That relieves high end-stress and insures uniform load distribution over the entire length of the roller. The result: *TRU-ROL* Steel Cage Bearings carry heavier loads over longer periods without excessive end-fatigue. They are less affected by slight misalignment or shaft deflection.

Investigate *TRU-ROL* Steel Cage Roller Bearings before selecting any bearing in the medium price range.

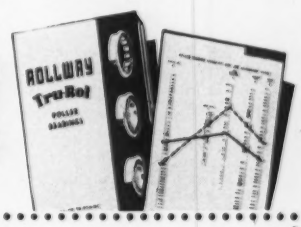


TYPE D

Rollway Metric Series Steel Cage Roller Bearings

● Rollway Metric Series Steel-Cage Bearings offer the greater load capacity of solid cylindrical rollers, plus the true right-line rolling of trunnion rollers turning in a rigid steel cage. There's no roller skew, no pinch out, no cam action. Design permits maximum bearing capacity . . . within small space . . . at moderate cost.

FREE CATALOG



ROLLWAY BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ROLLWAY BEARING CO., INC
549 Seymour St., Syracuse, N. Y.

Please send a free copy of New Tru-Rol Catalog with extra Alignment Charts.

Name_____ Title_____

Firm Name_____

Street_____

City_____ Zone____ State_____

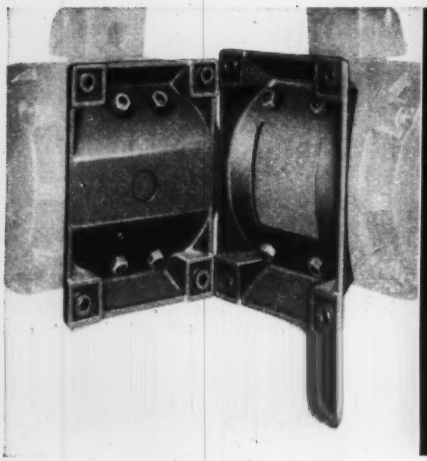
ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Milwaukee • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

—ITEM 178—

For More Information Circle Item Number on Yellow Card—page 19

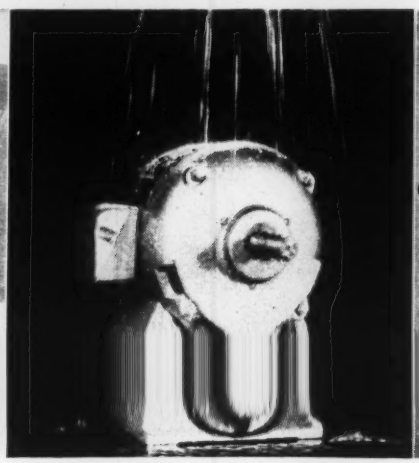
Single-Phase EXCLUSIVE ...totally-enclosed motor switch and actuator... in

You get these quality A. O. Smith motor features...



OPTIONAL FRAME MOUNTINGS

There's no need to change product design to use new NEMA frame sizes. A. O. Smith gives you frame mountings drilled to old and new specifications.



DRIP-PROOF CONSTRUCTION

Motor can be mounted in any position . . . drip-proof thru 360° cycle . . . simply rotate end brackets. No foreign matter can enter vent holes.

PRE-LUBRICATED BEARINGS

Shielded bearings assure protection against over greasing . . . provide even load distribution under all working conditions . . . quiet operating.

A. O. Smith integral hp motors

* Always clean

* Easy to service

THE secret of the totally-enclosed switch assembly is a sealed pocket in the end bell of the motor . . . a recess designed specifically to house the entire switch and actuator assembly. The pocket is then sealed with a cork-lined cover to prevent any type of dirt, dust or other foreign matter from *ever* coming in contact with these critical parts.

Service is a cinch. Because of the proven simplicity of the A. O. Smith switch design, service, even without the separately sealed feature would be practically nonexistent. Each switch is individually adjusted to the precise setting for long life and best electrical performance. As a result, it's almost impossible for contacts to burn out.

When you specify A. O. Smith integrals, you get motors that are application-engineered to match your particular product design. There's no need to adapt your product to the design limitations of conventional motors.

And remember — for your design or speed requirements, there's an A. O. Smith integral hp motor available to power your products. Integrals are built in a single-phase (1 thru 7½ hp) and polyphase (1 thru 150 hp) . . . in various speeds and frequencies . . . choice of frame mountings for either old or new NEMA dimensions . . . C and D flanges or special flanges as required.

Produced by one of America's great industrial concerns, these motors are backed by a national network of 270 strategically located factory service stations. There's one near you—ready to provide 24-hour service on all parts and service orders.

For more information on A. O. Smith integral hp motors, write for new Bulletin No. EM156.

Through research A.O. Smith *. . . a better way*

A.O.Smith

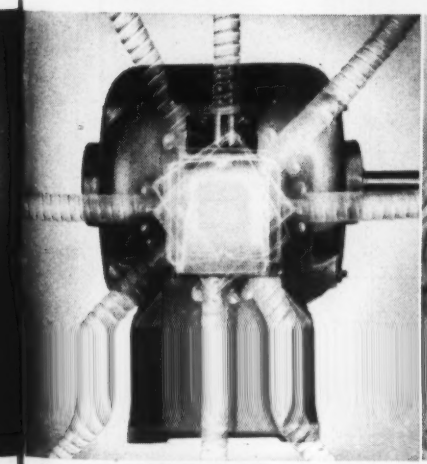
CORPORATION

ELECTRIC MOTOR DIVISION

TIPP CITY, OHIO

International Division: Milwaukee 1, Wisconsin

application-engineered to match your product requirements

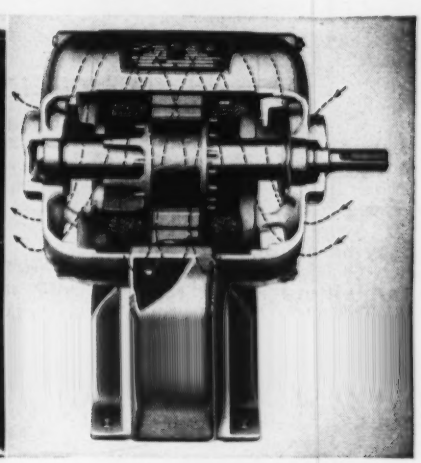


FULL-ROTATING CONDUIT BOX

Can be set at any angle. Designed to save motor space and speed installation. Loosen only three screws to rotate conduit base.

DYNAMICALLY-BALANCED ROTOR

Assures continuous, vibrationless, trouble-free performance and maintains long bearing life. Indestructible laminations are high-quality silicon steel.



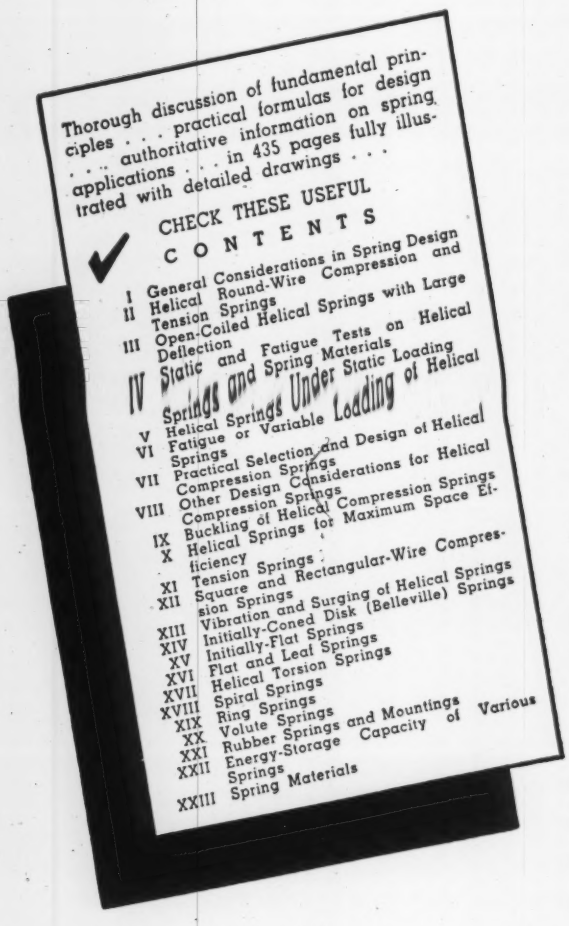
CONTROLLED THRU-VENTILATION

Cooling system designed for high-volume, low velocity air for maximum heat transfer. Temperature held to absolute minimum, assuring longer insulation life.

"mechanical springs"

By A. M. Wahl

FOR AUTHORITATIVE ANSWERS TO YOUR SPRING DESIGN PROBLEMS


Thorough discussion of fundamental principles . . . practical formulas for design . . . authoritative information on spring applications . . . in 435 pages fully illustrated with detailed drawings . . .
CHECK THESE USEFUL
C O N T E N T S
I General Considerations in Spring Design
II Helical Round-Wire Compression and Tension Springs
III Open-Coiled Helical Springs with Large Deflection
IV Static and Fatigue Tests on Helical Springs and Spring Materials
V Helical Springs Under Static Loading
VI Fatigue or Variable Loading of Helical Springs
VII Practical Selection and Design of Helical Compression Springs
VIII Other Design Considerations for Helical Compression Springs
IX Buckling of Helical Compression Springs
X Helical Springs for Maximum Space Efficiency
XI Tension Springs
XII Square and Rectangular-Wire Compression Springs
XIII Vibration and Surging of Helical Springs
XIV Initially-Coned Disk (Belleville) Springs
XV Initially-Flat Springs
XVI Flat and Leaf Springs
XVII Helical Torsion Springs
XVIII Spiral Springs
XIX Ring Springs
XX Volute Springs
XXI Rubber Springs and Mountings
XXII Energy-Storage Capacity of Various Springs
XXIII Spring Materials

Thousands of design engineers have discovered "MECHANICAL SPRINGS" by A. M. Wahl to be an important aid in helping them solve their spring design problems. Based on original research and practical applications, it has long been recognized as the outstanding work in its field.

"MECHANICAL SPRINGS" is filled with the kind of information that enables preliminary calculations to be made on the design of all types of springs: helical, disk, Belleville, flat, leaf, torsion, spiral and volute.

Mr. Wahl, an eminent authority on springs, and well-known for his development of the "Wahl Correction Factor", puts spring design on a rational basis. You will find that no matter what your problem . . . working stress . . . fatigue . . . buckling . . . or just plain maximum efficiency, the use of "MECHANICAL SPRINGS" will reduce the number of spring failures due to "guesswork" to a bare minimum, as well as save you time and materials.

A MUST for your design library . . . To get your copy fill out and mail this convenient order form TODAY!

Book Department
Penton Publishing Co.
Penton Building
Cleveland 13, Ohio

Send me ____ copies of "MECHANICAL SPRINGS" at $6.00 per copy

☐ **Remittance enclosed in which case book will be sent postpaid**

☐ **Please Bill Me**

☐ **C. O. D.**

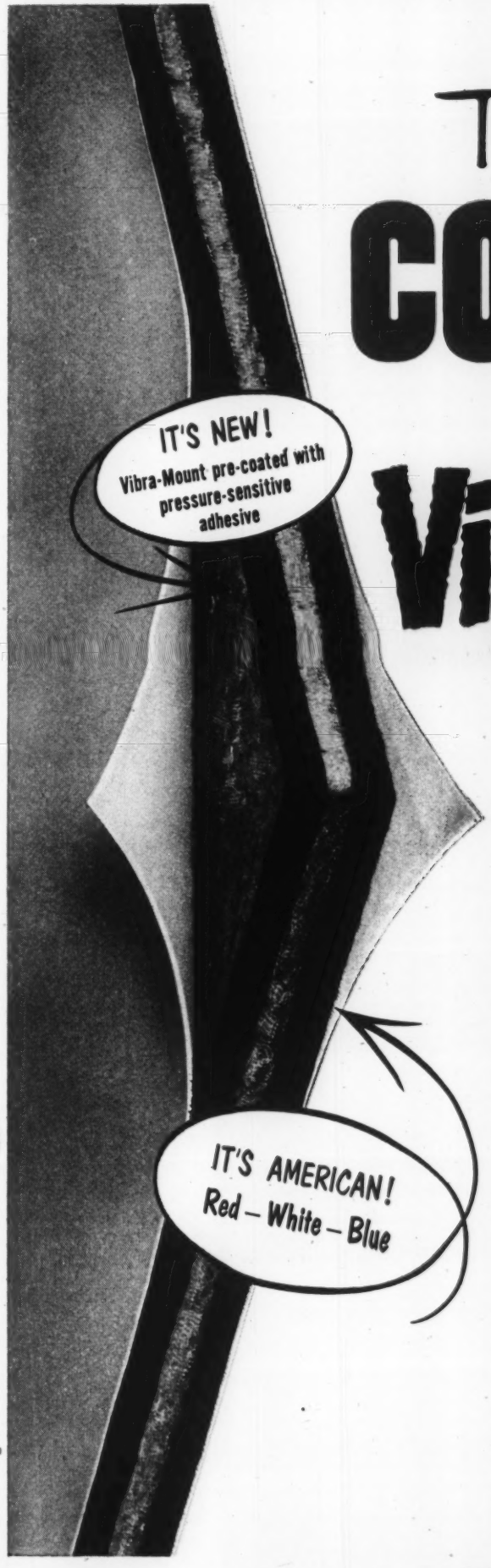
(Add 3% to orders for delivery in Ohio to cover State Sales Tax.)

NAME _____ **TITLE** _____

COMPANY _____

ADDRESS _____

CITY _____ **ZONE** ____ **STATE** _____



This FELT can CONTROL that Vibration!

When machinery has the shakes, put it on Vibra-Mount* Felt. This resilient cushion greatly reduces the amount of vibration transmitted to the floor, as much as 85%. People are happier, buildings safer. Vibra-Mount Felt is long lived because it takes compression with a minimum of set. In almost every case lag bolts are unnecessary, so machines can be rearranged with a minimum of difficulty. Write for FREE booklet, "How to Reduce Vibration." For technical information, ask for Data Sheet No. 10.

*T. M. Reg.

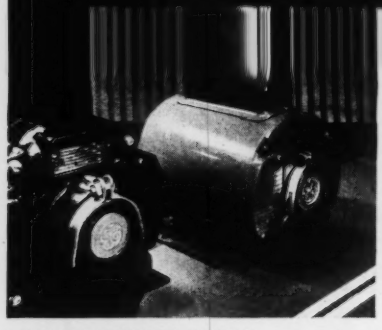
American Felt Company

TRADE MARK ®

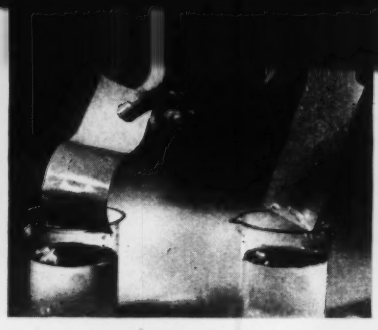
GENERAL OFFICES: 22 GLENVILLE ROAD, GLENVILLE, CONN.
SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Greenville, S. C., Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.

All these smaller, lighter G-E motors

ONLY G.E. OFFERS ALL THESE SUPERIOR FEATURES

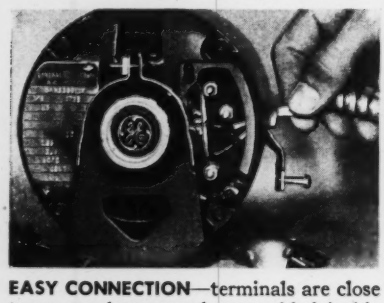


SMALLER, LIGHTER DESIGN—as much as 40% smaller and 50% lighter—speeds assembly and cuts product shipping weight.

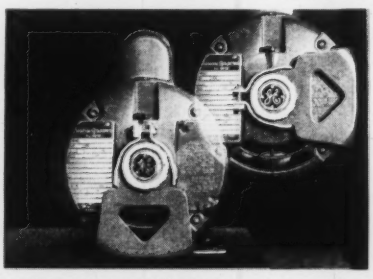


MYLAR* INSULATION (right): 35 times the moisture resistance, 8 times the dielectric strength of paper insulation (left).

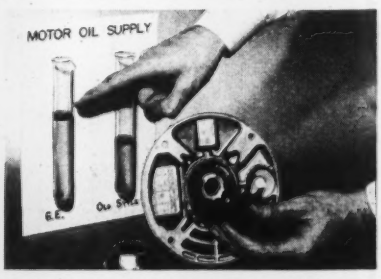
ALL-ANGLE OPERATION—lubrication is sure and protective when mounted in any position; no need for costly specials.



EASY CONNECTION—terminals are close to cover plate; speed-nut welded inside shell for fast connection from outside.



MOUNTING VERSATILITY—with resilient *or solid* cradle bases, you can rotate *any* G-E motor to meet your design needs.



DOUBLE LUBRICATION LIFE—50% more oil capacity and more efficient oil retention system cut G-E motor maintenance.

*DuPont trade-mark.

are available now in ratings you need

Act today to cut YOUR costs on material, assembly, shipping!

You have the opportunity to save *now* with smaller, lighter fractional-hp motors. General Electric, which pioneered these advanced motors three years ago, now offers prompt delivery on more than 850 *basic* models—including the right motors for *your* products.

IMPROVED PRODUCTS—plus savings in material, assembly, and shipping—await your conversion to these "years-ahead" G-E motors. For example: a compressor builder cut over-all manufacturing costs 25%. A pump manufacturer doubled sales of his streamlined product. A third manufacturer has reduced his shipping costs by 35%.

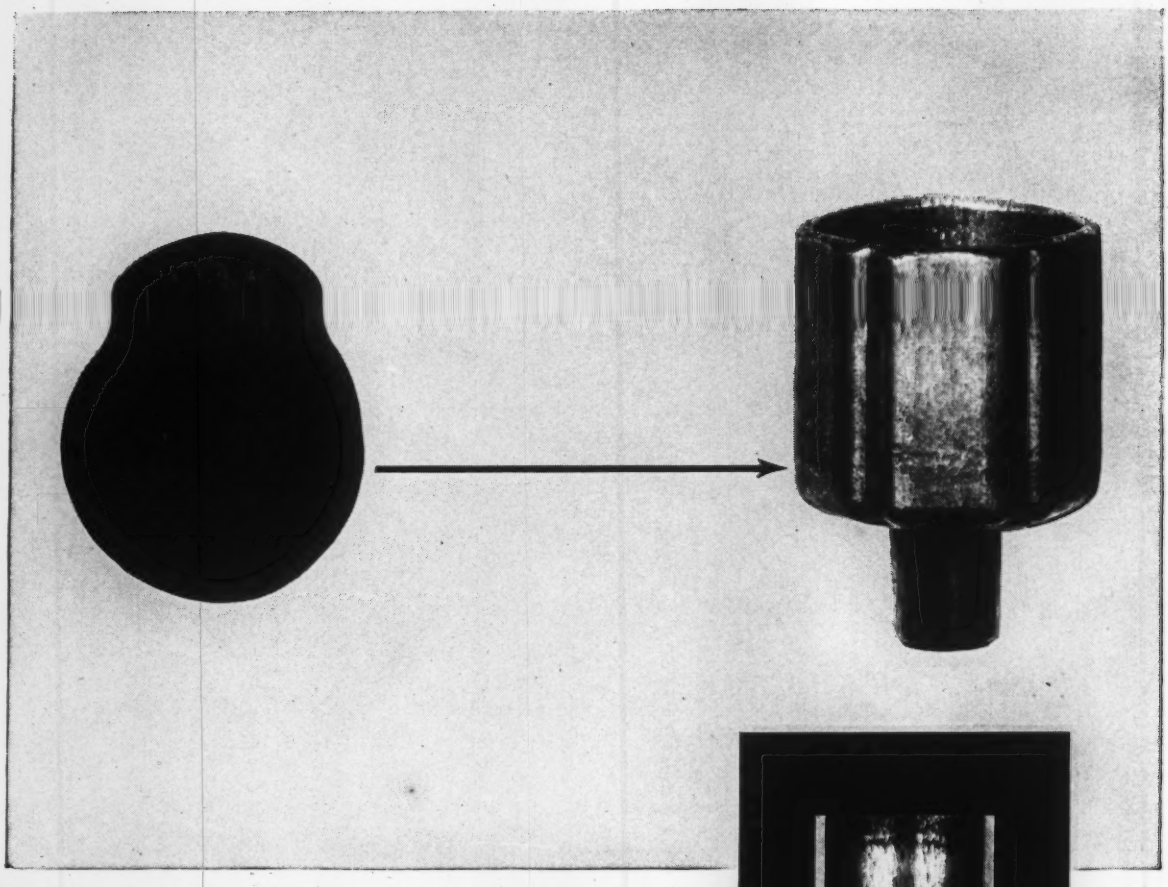
PROVED PERFORMANCE of smaller, lighter G-E motors on nearly 4,000,000 products demonstrates the superiority of the features listed at left.

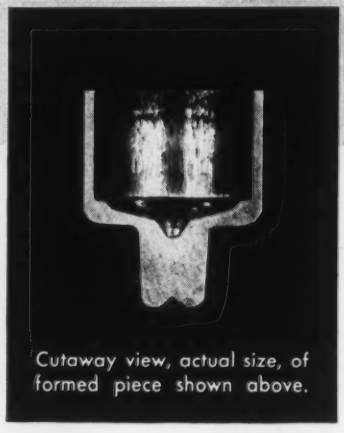
TO HELP YOU realize *all* these benefits, G.E. offers application aid from engineers who have helped apply these advanced motors to all types of products.

WHY WAIT? Prompt delivery of the G-E motors you need can help you carry out a quality-boosting, cost-cutting program on your products without delay. For full information, including case histories of actual cost savings with G-E fhp motors, contact your G-E Apparatus Sales Office today. Or write Section 702-23, General Electric Co., Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC





Cutaway view, actual size, of formed piece shown above.

COLD FORMED IN ONE OPERATION

—with Bonderite and Bonderlube!

An experienced production man looked at this blank and the formed parts and said flatly, "It can't be done!" But *it is being done* — in one operation — on a production basis of thousands of units per day.

The blank is treated with Bonderite, and then with Bonderlube. This combination works with remarkable effectiveness.

These two Parker products effect big savings in other ways besides raising production levels. Tool and die breakage declines sharply, fewer process anneals are necessary, operation is simplified, scrap is minimized, and machining operations are reduced.

Cold extrusion, with Bonderite and Bonderlube, may hold the key to cost-cutting for you. Write for information!

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

Since 1915— leader in the field

PARKER RUST PROOF COMPANY

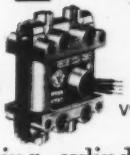
2193 E. Milwaukee, Detroit 11, Michigan

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

—ITEM 182—

For More Information Circle Item Number on Yellow Card—page 19

25,000,000 CYCLES*

Skinner solenoid valves  are ideally suited for use in high-speed production lines. They perform lubricating, cylinder control, blowing and ejecting functions in hundreds of applications, such as drilling stamping, pressing and riveting. Skinner valves provide fast, dependable and trouble-free operation. They're leakproof, rugged, and *simple to inspect.* Available in more than 100,000 variations, so you're sure of finding the valve that is perfect for *your* particular application.

V9 Four-Way

V5 Universal

Call in a Skinner engineer *first* to help you with your solenoid valve problem. With us, no problem is too great, no quantity is too small. Write for Skinner's new solenoid valve catalog . . . on your letterhead, please.

*Special Skinner solenoid valves have proven operable up to 25,000,000 cycles in specific applications.

SKINNER

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION • SKINNER CHUCK COMPANY

SKINNER ELECTRIC VALVES

SOLENOID VALVES

115 Edgewood Avenue
New Britain, Conn.

WORLD-WIDE REPRESENTATION

—ITEM 183—

(Advertisement)

The world's largest opens a new era of

ABOUT one year ago, the largest die-casting machine in the world was completed and put into operation by Doehler-Jarvis Division of National Lead Company in cooperation with Kaiser Aluminum & Chemical Corporation.

Recently, the huge machine successfully produced the largest aluminum die-casting ever made—a six-cylinder in-line engine block weighing about 130 pounds less than a similar gray iron block.

The successful production of such a large and complex die-casting points the way to the design of large and economical die-cast aluminum parts for many industries.

Such parts would benefit from all the advantages of the die-casting process, which is inherently suited for mass production of parts requiring close dimensional tolerances, smooth surfaces, clean and sharp detail and thin metal sections.

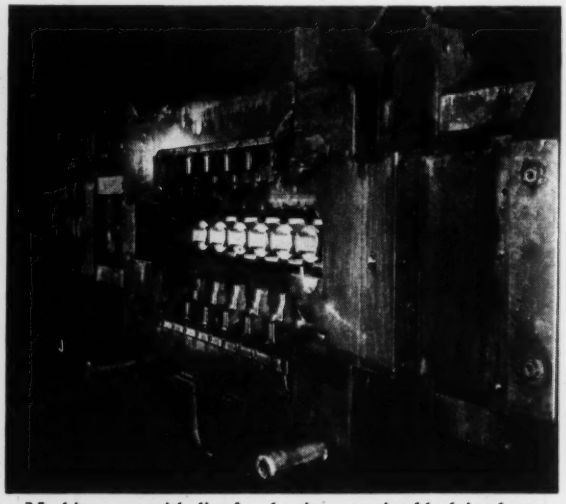
It is also possible to cast many details to size on the large press. In many cases, this eliminates the need to drill holes and other machining operations. Threads may often be cast to size, thus eliminating a threading operation. Cast-in metal inserts are readily included in die-castings.

Overall dimensional accuracy is another feature of die-castings that is important to many parts. This reduces the amount of finish allowance when parts are machined to a prescribed overall dimension.

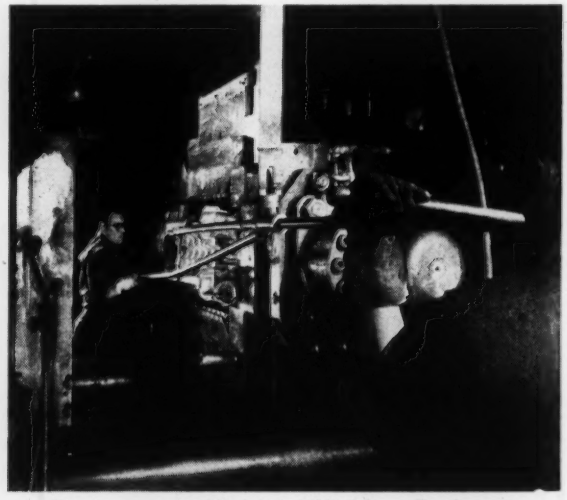
In addition, die-castings are generally lighter in weight than the equivalent parts made in sand or permanent mold, because thinner metal sections and less draft are permissible.

The metal quality of die-casting is more uniform than in a typical sand casting. Therefore, service life is more uniform.

Product designers and engineers should investigate this new Doehler-Jarvis Division of National Lead development in aluminum die-casting without delay to see if your existing or new designs can take advantage of the new 72" machine.

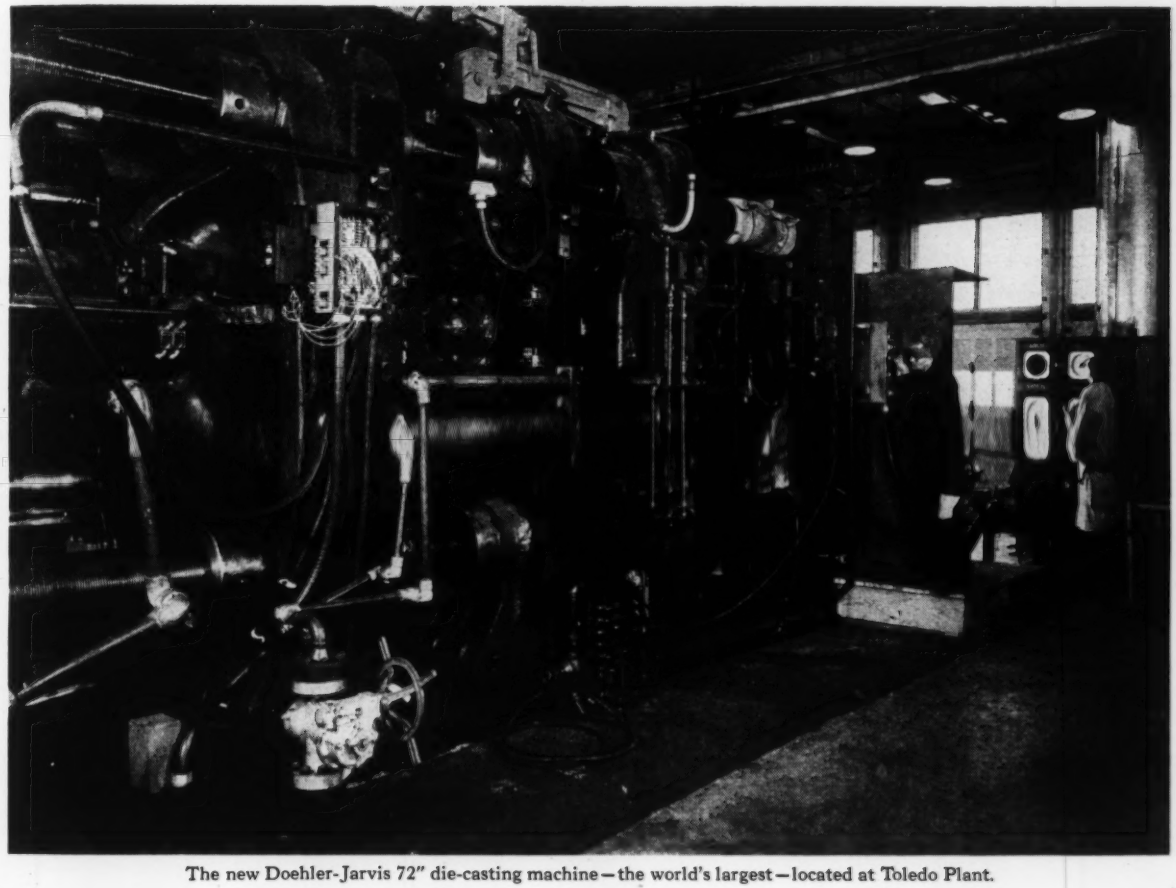


Machine open with dies for aluminum engine block in place.



Aluminum engine block being lifted from die after cast.

die-casting machine product design!



The new Doehler-Jarvis 72" die-casting machine—the world's largest—located at Toledo Plant.

Engine blocks were die cast by Doehler-Jarvis.

If you need assistance with aluminum . . .

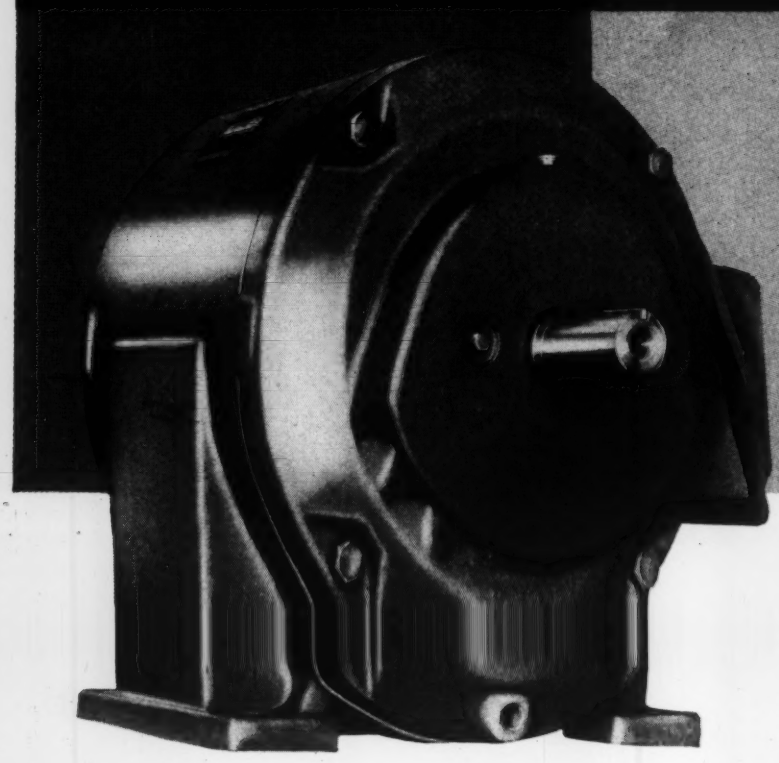
Let us work in partnership with you. We are eager to share our knowledge of aluminum and engineering skill. Development engineers will gladly provide engineering service and counsel on design and alloy selection which may give you a better product at a lower cost. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California; DETROIT OFFICE, *1414 Fisher Bldg., Detroit 2, Michigan, Phone Trinity 3-8000.*

Kaiser Aluminum

setting the pace—in growth, quality and service

—ITEM 184—

Totally Protected



FROM CORE TO COVER

RELIANCE *Totally-Protected* MOTORS

The total protection concept of design and construction armors Reliance A-c. Motors against everyday hazards, with little or no maintenance. Total protection is made up of extra features like:

Slot cell insulation of Double Backed Mylar

Dynamically balanced rotor for vibrationless operation

Entire insulation system impervious to acids, moisture and oils

Metering plate regulates grease flow to bearing

Ventilation louvres positioned high and dry in end brackets

There are 100 of these extra core to cover protection features in Reliance Motors. Each point is covered in our bulletin, "Check the 100 Facts". Why don't you write for one and get all the details? B-1510

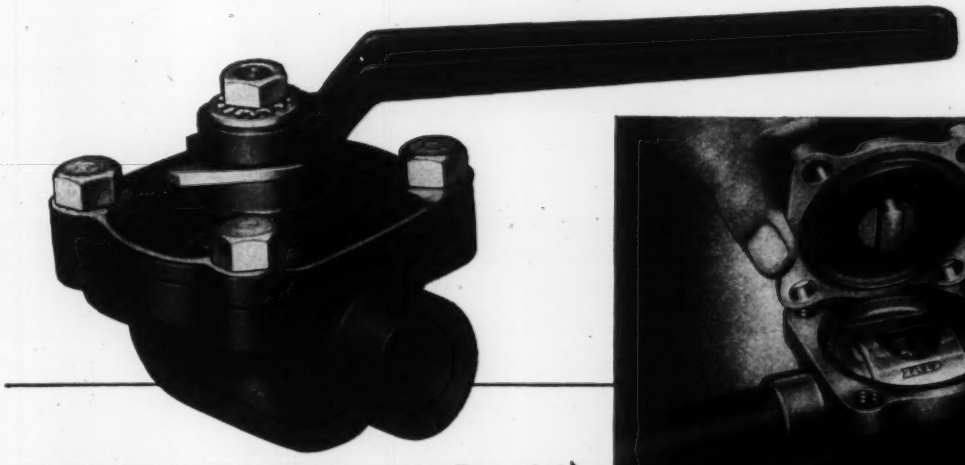
RELIANCE ELECTRIC AND ENGINEERING CO.

Cleveland 10, Ohio • Offices in Principal Cities

Canadian Division: Welland, Ontario

—ITEM 185—

For More Information Circle Item Number on Yellow Card—page 19



FAST, LOW-COST CHANGE IN DIRECTION OF FLOW. Removal of the body cap permits reversing the cage assembly to allow change in direction of flow. In addition, this feature lets you change seat material, and clean the valves thoroughly and quickly — *without removing the valve from the line!*

INTERCHANGEABILITY of seat material to meet your operating requirements is another feature of the Rockwood Top Entry Ball Valve. Seat can be furnished in Buna-N, Neoprene, Kel-F, Teflon, and Nylon.

EASY INSTALLATION AND OPERATION is permitted because of the new handle design. This new design allows the handle to be placed in any of *eight positions!*

Now!... New Rockwood Top Entry Ball Valve

. . . A new concept in valves that saves you money and time!

Made of bronze the new Rockwood Top Entry Ball Valve is ideal for handling oxygen and hazardous liquids as well as water, oil and gas. It carries 300 lbs. per square inch on water, oil and gas and 400 lbs. per square inch on LP gas and is available both with sweat ends and screw ends, in sizes ½", ¾" and 1".

Write for complete data on this unique full round pipe size flow.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

Distributors in all Principal Industrial Areas

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
728 Harlow Street
Worcester 5, Mass.

Please send me complete information on Rockwood Top Entry Ball Valves.

Name.....

Title.....

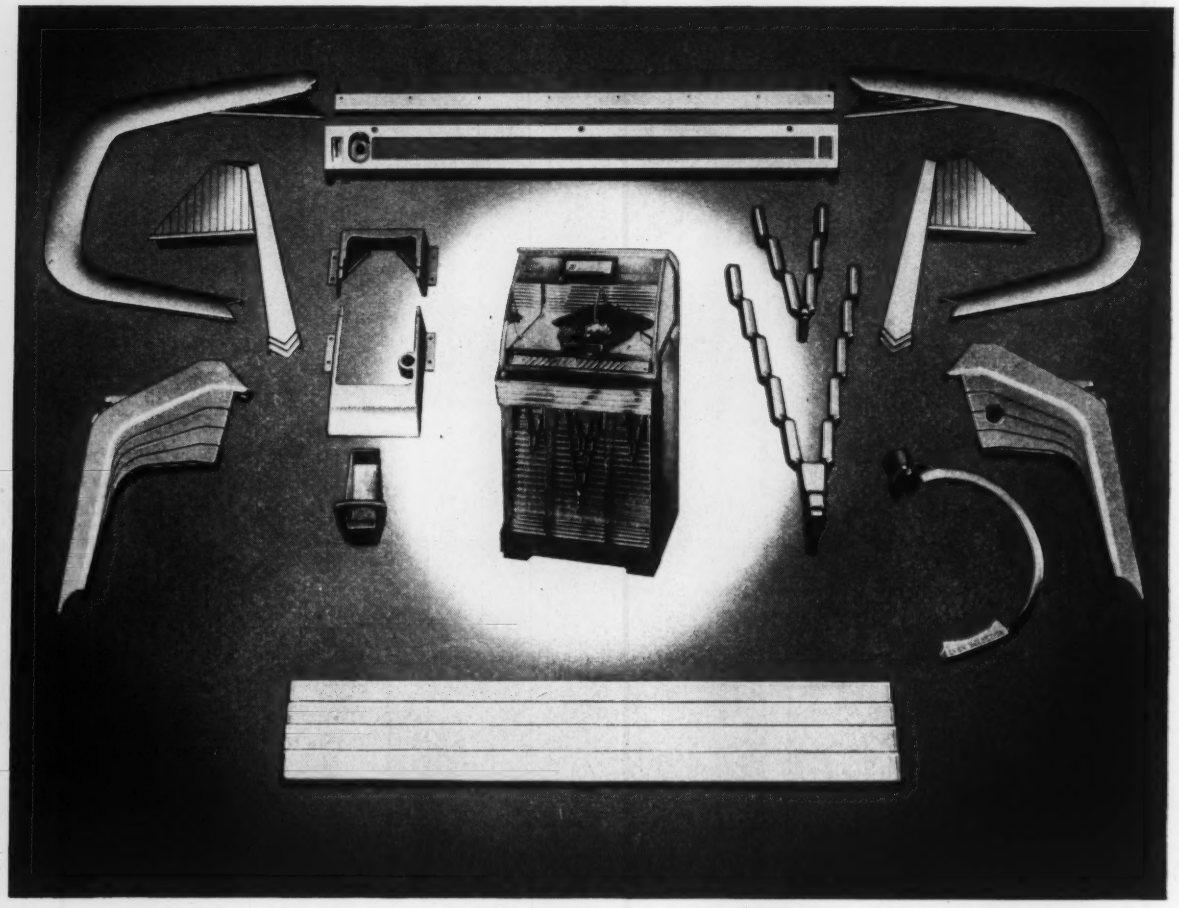
Company.....

City.....

Zone....State.....

—ITEM 186—

WHY ZINC RATES FIRST IN DIE CASTING • NUMBER 7 OF A SERIES



ease of assembly for ROCK-OLA

Much of the cost and many of the headaches involved in turning out a product like a coin operated phonograph are centered on the assembly line. Rock-Ola engineers, like those in many other fields of product engineering, minimize their assembly problems through the well-planned use of ZINC Die Castings.

The castings shown here comprise most of the exterior trim on the latest Rock-Ola Hi-Fidelity music maker. Because the unusual shapes can be die cast, the eye-catching decorative effects—highly important to the success of this product—are achieved with an absolute minimum number of components.

Since all ZINC Die Castings in a long production run are identical in size (with precisely located fastening elements) assembly is rapid and trouble-free. Furthermore, the smooth, as-cast surfaces of ZINC Die Castings require no special preparation prior to the application of beautiful, durable chromium plate by standard finishing procedures.

Send for your copy

Other important reasons for the ever-growing popularity of ZINC Die Castings will be covered in this space in the months ahead. Send for a copy of our brochure and contact any commercial die caster for the answers to your particular production problems.

ZINC
FOR DIE CASTING ALLOYS

The New Jersey Zinc Company, 160 Front Street, New York 38, N. Y.

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

—ITEM 188—

For More Information Circle Item Number on Yellow Card—page 19

MACHINE DESIGN
JANUARY 26, 1956

Partners for Progress

ENGINEERS across the land must view with mixed feelings the recent conflict at Lockheed. According to news reports, a sizable number of scientists engaged on missile development resigned on the issue: Who should control missile research efforts—the scientists or the engineers?

This is certainly a new twist. In the past engineers have had occasion to feel irked at the drag on technical progress imposed by unsympathetic management. Now we have the unusual spectacle of scientists feeling that their efforts are hampered by engineers with inadequate scientific understanding.

Perhaps such differences are only to be expected. They are part of the growing pains of an expanding technology which is entering new and fantastic dimensions.

The scientist who feels he should have a stronger voice in engineering and management must remember that in industry he is a "specialist." His special strength and value lie in his single-minded dedication to scientific development—a full-time job demanding the utmost concentration. His continued efforts on new and startling problems are sorely needed. Whether proper utilization of the scientist's skills should also include participation in, or supervision of, engineering and production functions is open to question.

The engineer, on the other hand, is likely to be behind the scientist in the rigor and discipline of his training. Perhaps he must acknowledge a subtle change—a new climate which may ultimately place him, technically, in much the same relationship to the scientist that the mechanic is to the engineer.

The engineer's value in any program based on advanced scientific research is clear. It will be in proportion to his ability to understand the scientist's objectives and to translate them into useful designs at reasonable cost.

The public airing of differences between closely allied professional groups may seem disturbing. But it will have value if it focuses attention of engineers and scientists themselves on the need for mutual understanding.

The vistas opening up in such current projects as missiles, satellite vehicles and nuclear power, to name just a few, are of unbelievable magnitude. Solution of the manifold scientific and engineering problems will require teamwork of the highest order. With co-operation based on mutual respect there is no limit to how far and how fast such teamwork can go.

Colin Carmichael

EDITOR

Ten key factors

Successful Product Development

ONE EXECUTIVE, a man who is both an administrator and a well-qualified engineer, sums up his company's product expansion thinking in words to this effect:

"Our job is to gain supremacy over competitors by doing a better job in a shorter time in bringing out new products. These products must offer new functions, better performance or lower cost. Each of these values is readily marketable.

"Our business just won't stand still. Either it will grow or shrink. We plan to have it grow. The job won't be easy, but we're going to tackle it. If we can't take it, we want to know why."

This is a clear-cut expression of the competitive picture and the role new products play in achieving superiority.

Unfortunately, however, product development programs frequently fall way short of anticipated goals. The manpower and ammunition of these programs are costly if not offset by profitable results in the form of tangible products. Analysis reveals the reasons for failure of product programs. They fit into rather well defined patterns. pinpointing ten major pitfalls that must be avoided.

1—Take time for development

Product development takes time. Many manufacturers are more than preoccupied with their going products. This means that development projects must be put off, often until too late. Business mortality figures attest to this fact.

An inventory of departmental operations will reveal where time is available and where departments are overworked. Underscheduled departmental time can be applied to business development assignments and other time must be made available.

To maintain an average growth curve, experience has shown that product development activities—research, development, process studies, market studies and sales expansion—should represent on the average a solid 6 per cent investment computed on total dollar sales volume. This amount can be increased or decreased; growth will be affected correspondingly.

Stagnation is the penalty for neglecting business development. Not too long ago the chief executive of a medium-sized corporation remarked that business development was one of his major concerns because his firm hadn't accomplished anything new in the past ten years. There had been a lot of talk but no action. It didn't take much exploration to discover that everyone in the organization was too busy with day-to-day jobs.

Being too busy with today's job offers competitors the best possible opportunity to capture the market with new and improved lines.

2—Know the steps

Product programs that take into account changes in consumer demands, new product developments by competitors, and the many other pertinent factors, require a thorough understanding of each step in the course of development. To assure successful product development programs, it is important to make certain that those who are assigned to this important job have such understanding.

Every product sold today started somewhere as an idea. Successful products represent ideas that have been developed through a sequence of logically ordered steps designed to lead to marketable products. One of the major pitfalls in product programs results from not knowing these steps.

Here are some examples to prove this point. One machine tool builder neglected to inquire about the use of new metals in a particular industry while designing and developing a single-purpose

By Philip R. Marvin
Research Economist
American Viscose Corp.
Philadelphia, Pa.

machine that was virtually worthless because of a subsequent change in material specifications in the part processed. The change could have been easily anticipated.

Another manufacturer was forced to undertake extensive redesign of a new product because building codes and electrical codes had not been duly considered. A third manufacturer was unable to sell an item because color of the product failed to have competitive eye appeal.

In each of these instances an essential step in product development was omitted.

3—Join knowledge with ability

Specialized talent is a prerequisite to success in product development activities. The group that tackles product development projects must represent the right mixture of capabilities.

Regardless of the way the group is brought together, from entirely within the organization, partially within and partially outside the organization, or as a wholly outside group, one thing should be certain—all of the required talents must be represented on the team.

Few companies can expect to find within their organization all of the kinds of specialized help needed for the development of new products. Moreover, few firms will find that they can profitably use on a full-time basis the varied array of talent needed for the job at hand. But, whatever the circumstances, specialists must be made available when needed or the product development project will suffer. In the long run this means lost dollars in sales. No adequate substitute exists for specialized talent. Vacancies are more expensive than the personnel required to fill them.

As technology advances, competitive requirements change. Some talent is no longer required and new needs arise that must be satisfied to maintain a competitive product development program.

Frequent examples of deficiencies in this direction are encountered in the heavy equipment industry. Design often becomes merely a matter of making minor detailed changes in drawings. These

Sound product development programs are the key to company growth and expansion. Here are ten questions useful in analyzing such programs. Answers to these questions point to strengths and weaknesses, and give command of intelligence necessary in product programming.

1. **Do we have time to do the job?**
2. **Do we understand all of the problems involved?**
3. **Do we have the ability to tackle product development programming?**
4. **Do we have the experience necessary?**
5. **Do we know how to conduct a successful product development program?**
6. **Will we be able to see development programs in their proper perspective?**
7. **Are we familiar with the practices of our competitors?**
8. **Can we work with an independent viewpoint?**
9. **Do we have the freedom necessary to work?**
10. **Do we have the plant and facilities for product development?**

Sound product development programming depends on "yes" answers to all of these questions. Most product programs fail to pass all ten tests, but those that do are destined to direct the corporation toward growth.

drawings may be 25 years old or older. Forging ahead like a team of snails, such companies are quickly engulfed by more progressive companies whose capable staffs are applying modern stress analysis techniques, advanced metallurgical and fabrication practices, new alloys, newly developed design principles, and rational testing procedures to newly designed units.

The ability to apply new knowledge is just as important as knowing that it should be applied, and is essential to productiveness. Knowledge must be joined with the ability to apply this knowledge when new products are developed.

4—Draw on experience

Product development assignments executed by competent and experienced personnel move swiftly and surely toward desired objectives. Experience lends efficiency. Where experience is not available, the staff must be supplemented to provide this important ingredient.

This point might be emphasized by saying "Don't put a boy on a man's job." Both may know how to cut wood, but the man's added efficiency will usually more than offset the lower hourly cost of the boy's labor.

The same holds true in product engineering. Without any reflection on the engineer directly out of school, his efficiency will be low until he has acquired experience through practice. He will be a better man ten years later if he has had the wise counsel and guidance of experienced men.

One aircraft executive has had bitter experience with inexperienced but otherwise capable engineering personnel assigned to a product development program. The engineers on the job were too green. They had the time, they knew the steps and had ability, but they lacked practice and, as a consequence, their efficiency was unsatisfactory. Hard work was not enough to maintain the status quo of the corporation's sliding industry position. They couldn't move fast enough to keep ahead in a rapidly advancing aircraft industry. The job called for experienced men.

"What's wrong?" may well be asked if these men had the time, knew the steps, and had ability. Simply this, too much time was being used to learn the way around and to develop the skill that must come from practice in any profession. This process takes time.

Practice is the bedrock of performance. Ability alone is not enough. Product programs need men who have acquired the experience that enables them to move with assurance and dispatch.

5—Develop planning techniques

Techniques are tools in product programming. Techniques are tested systems of organized attack on problems. They make possible efficient application of experience and ability in problem solving.

Good techniques for approaching problem areas are usually developed by those who have sufficient repetitive volume of product development work. Practice permits development of efficient systematic ways of solving problems. Sound techniques develop from the repeated application of ability and experience.

Techniques for approaching product problems vary both in degree and in kinds. Highly developed systems of product programming are generally found where results have been outstanding. Systems range from an engineer's simple checklist to volumes of procedural data covering every major department in the organization.

The executive committee of one corporation schedules weekly meetings at which the director of engineering reports on new product ideas and studies. This report is based upon a carefully established procedure for systematically searching for and screening new ideas. Current and comprehensive reporting is made possible by techniques for quickly appraising ideas, including both technical and market aspects.

A pioneer products department has been established in this corporation. Here new product ideas have immediate attention.

These techniques have been developed to provide the best possible method of expediting a steady flow of new products from engineering into production and selling channels.

6—View problems in perspective

For some years one equipment-parts manufacturer has been attempting to develop a consumer item to sell under a proprietary name. Attempts have been unsuccessful. The principal reason for failure has been that, because of the inherent nature of the business as a parts manufacturer, understanding of consumer item concepts is foreign to customary thinking.

As a parts manufacturer, these people are spoon-fed orders for specific items. In the consumer field, they must create a product and a market and, in addition, protect both of these. An understanding of problems involved is essential to the success of any product program.

After association with daily operating problems for a number of years, few individuals can be sure that they have the ability to view problems with perspective. This "see yourself as others see you" is invaluable in growth planning.

In a number of cases, lack of perspective has been the major contributing cause of product program failure. No product stands alone. Each product casts a shadow on other products both in related and nonrelated lines. Perspective is the ingredient in product analysis which makes possible evaluation of these significant product relationships.

"How can perspective be developed?" may be asked. Experience and study of a variety of product development programs and their history are the only available answers.

7—Know your competition

Product development requires a thorough knowledge of the industry. Familiarity with the state of the art and technology, as well as trade customs, provides the background for evaluating and assaying the soundness of specific product ventures.

Associations and trade councils often provide clearing points for such information. These groups generally are only adequate in part and their work must be supplemented to achieve effective programs.

One corporation follows the practice of assigning to one engineer in each major product division the following specific responsibilities:

1. He must familiarize himself with the trend of the industry, with particular reference to style, technology, consumer acceptance and price trends.
2. He must maintain records, including illustrations, trade literature and operating instructions, covering competitive items.

This engineer has the job of recommending changes, additions or eliminations affecting the line so that products will have the highest competitive value to the consumer.

Consumer acceptance is the primary and final product criterion. It provides the only commercial and economic basis for justification of product development. These relative values must be weighed in the competitive scale of the market.

8—Break away from the past

Product development should be undertaken in an atmosphere of complete independence with the purpose of achieving certain objectives. Previous methods and ways of doing the job should be cast aside. Attention should be focused on the technical fundamentals and customer requirements involved.

The helicopter resulted from a fundamental study of flight principles and requirements. The jet engine resulted from a similar approach to the aircraft power plant. Today, metal can be cut with a tool, ground with an abrasive or removed by sparking and electrolysis. All methods are available as a result of fundamental studies of metal removal.

In product development one should commence by learning to forget the past.

This advice is not easy to follow. Years of disciplined thinking develops "ruts" that guide thought into well defined channels. Where this is the case, engineering replacements in the product program staff are in order to revive the vitality of the creative thought process.

9—Create freedom to move

Development engineering requires freedom to think, to move and to act. It is an exploratory process. Ideas, concepts and facts must be gathered, cataloged, screened, analyzed and acted upon. The freedom to do these things, however, is not one without reservation. First, basic ideas must not be revealed and second, the identity of the corporation should not be disclosed.

Many good ideas have been given away to competitors through carelessness. Technical people must be properly trained to respect and protect the idea assets owned by corporations.

This consideration is well pointed up by the experience of one corporation where several good product ideas have been lost to competitors. During the exploratory stage competitors learned that engineers were studying certain new product ideas. Competitors liked the idea and moved with more speed, capturing both the idea and the potential market.

Providing freedom to move not only accelerates programs but provides a firm footing for their advancement. Free from direct association with the corporation identity, product development activities move with rapidity while at the same time preserving anonymity.

10—Provide adequate facilities

At the outset it is difficult to define plant and facility requirements. Full requirements can't be determined in the early stages. For this reason, facilities should be flexible and quickly available. No phase of exploratory programs can safely be neglected because of lack of facilities.

While complete development facilities are costly to maintain, unless they are fully utilized, they are nevertheless essential to the success of any product development undertaking and must be available.

Programs repeatedly run into difficulty due to lack of facilities. One manufacturer had competent engineers but lacked facilities for life-testing final models. The results of the new product venture were disastrous. Shortly after the product was introduced to the market, a design weakness became apparent, making it necessary to recall the product for extensive and costly repairs.

It took years for this manufacturer to recover from the loss of trade acceptance suffered as a

consequence—"for the lack of a nail, a shoe was lost."

The human element

In analyzing the ten basic aspects, or "pitfalls," of product programming, the discussion has centered about the men, money, machinery, and time elements involved. Of these four, manpower generally presents the greatest problem.

Often it is difficult for men within the organization to be objective about product requirements. Viewpoints are narrowed and colored by constant concern with time-consuming, daily operating problems. Men are bound to worry the question: "How will this affect my job?" Product development must transcend any such subjective manpower limitations.

In the final analysis, there are only three ways of solving the manpower problem:

1. Take up the slack. Use those men and facilities that have some "free" time.
2. Assign jobs to people who are already busy.
3. Add "outside" talent to the organization.

Those companies that have capable people who aren't too busy and who are qualified for product development assignments are indeed fortunate. Where long-range programs of sufficient size to keep a staff busy can be coupled to commitments to support the cost, hiring policies can be pursued. If these don't apply, the best approach is to get "outside" help.

In any event, product development programs must "roll." Executives plan growth for the years ahead and stockholders look for results.

Programs should be designed for long-range growth and continuing prosperity. Severe economics of competition are imposed on those who attempt the job. The goal, as always, is to develop sound products, in the shortest time, at the lowest cost.

A Future Article will deal with the details of analysis of product development programming. A related topic, product diversification, was treated in December, 1955.

Polystyrene Prototypes for Investment Casting

PRODUCT development time and costs can be reduced with the use of polystyrene prototypes for investment casting. The method, developed jointly by Precision Metalsmiths Inc. and Bell Aircraft Corp., has been found to be a fast, inexpensive cut and try method. A design or an alloy can be proved without a costly investment in tooling.

Machined plastic parts, left, are assembled into the pattern, right, to make a development pattern for investment casting

First, the part is machined from polystyrene plastic, allowing for proper tolerances and shrinkage. If the piece is complicated, it may be made up of several plastic pieces bonded together. After machining, the plastic part is used as an expendable pattern and investment cast in the alloy desired.

Changes in the cast part may be incorporated by merely making a new plastic piece and recasting. There are no dies to be revised or parts to be hogged out of solid metal. Guesswork is eliminated by making experimentation less costly and less time consuming.

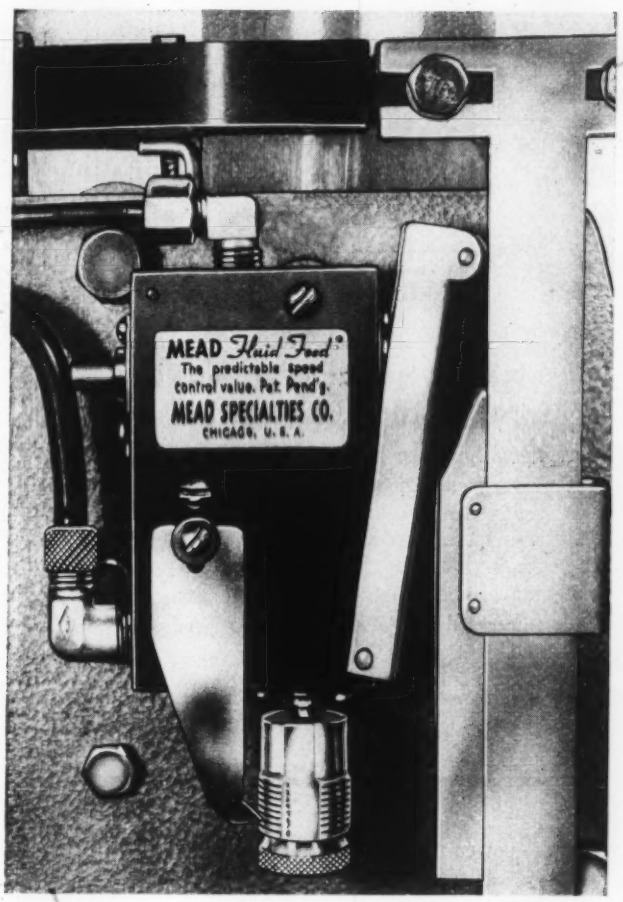
"It seems to me that in any manufacturing corporation, you gentlemen of the engineering profession have two very important functions to perform.

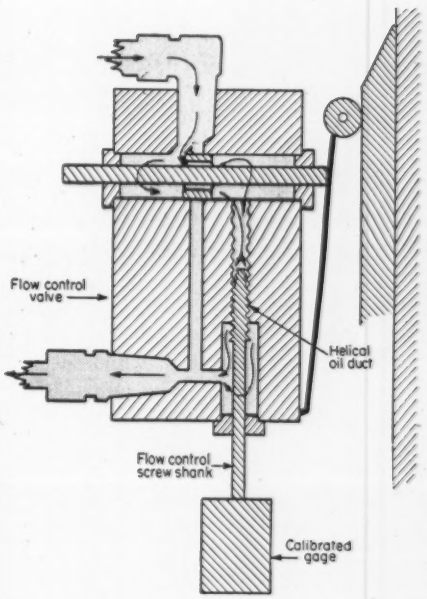
"The first is to design new products which will attract the customer and, if possible, put your company ahead of competition.

"The second is to make constant improvements in existing products or the methods of producing it, so that it will do more and cost less.

"These are not new problems to you, of course. They are just what you do every day in the year. The only difference is that as the market becomes more fiercely competitive, the tempo of your activities must be stepped up. You have to do more of both things. And, you have to do them faster, if possible." — CHRISTIAN E. JARCHOW, *executive vice president, International Harvester Co.*

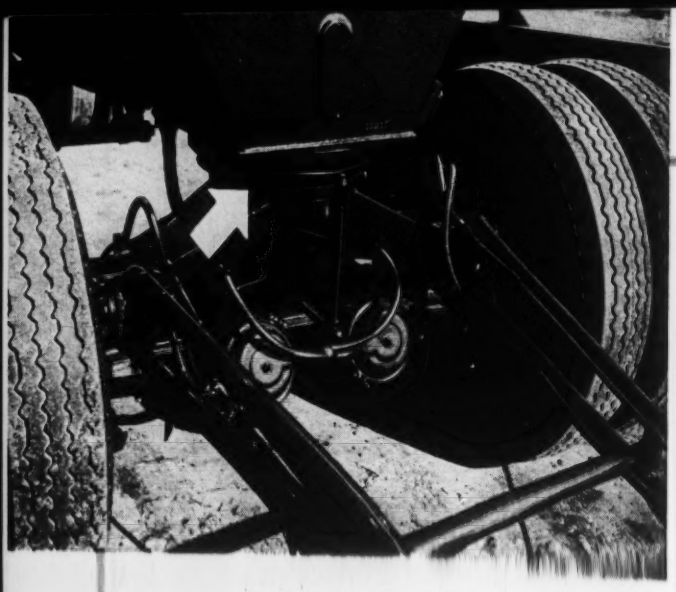
scanning the field for Ideas

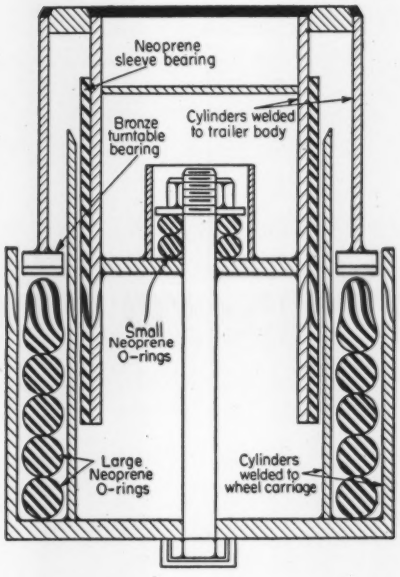




PRECISION CONTROL of fluid flow rate through a hydraulic valve is provided by an adjustable-length oil duct design. Developed by Mead Specialties Co. for use in air-hydraulic drill-press feeds, the valve has a helical flow-control passage formed by the clearances between mating male and female threads of a control screw assembly. Oil flow rate is controlled by hydraulic friction which is directly proportional to the length of this helical flow channel.

Rate of flow, and thus feed rate, are accurately indicated by a calibrated gage and pointer on the control screw and valve assembly.



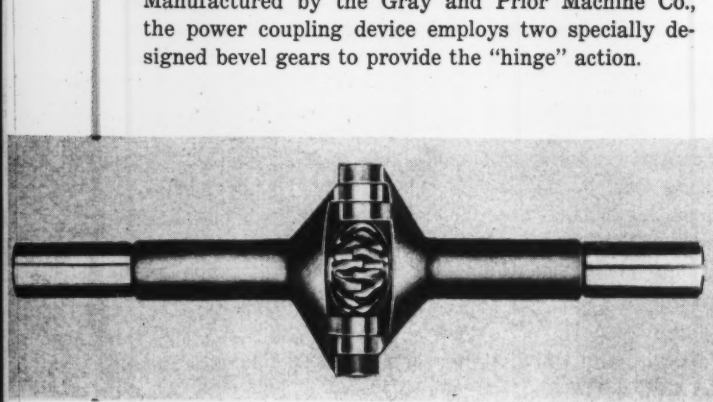


RUBBER SPRING SUSPENSION made up of stacks of O-rings absorbs shock loads and vibration in heavy-duty axle assemblies. Used in Collett Tank Lines trailer hitches ("fifth wheel" in truckers' language), the design reduces weight of conventional steel spring construction and simplifies maintenance and repair problems.

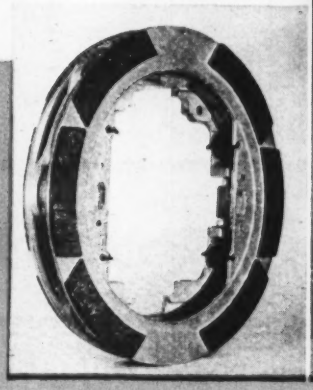
Essential elements of the assembly are four concentric metal cylinders, five large O-rings (12-in. ID and 2-in. section diam) and two small ones, and a synthetic rubber sleeve bearing. The O-rings and sleeve bearing are made of Neoprene for maximum oil resistance. Two of the cylinders are welded to the wheel carriage, and the other two to the trailer body.

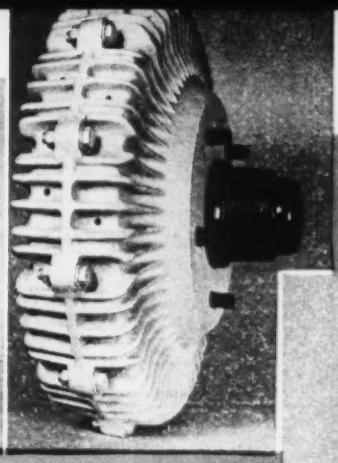
In service the large O-rings, which are submerged in oil, absorb vertical shock and vibration when the carriage and trailer move toward each other. The two smaller O-rings under the nut and washer of the king bolt absorb and minimize recoil bounce. The sleeve bearing, which transmits drawbar pull, permits some axial misalignment and absorbs horizontal shock.

HINGED GEAR JOINT permits operation of power transmission shafts "around corners" at angles up to 140 degrees. Although intended primarily for use on hand-operated remote controls, the design is also applicable to out-of-line power transmission members where load requirements are in the fractional horsepower range. Manufactured by the Gray and Prior Machine Co., the power coupling device employs two specially designed bevel gears to provide the "hinge" action.



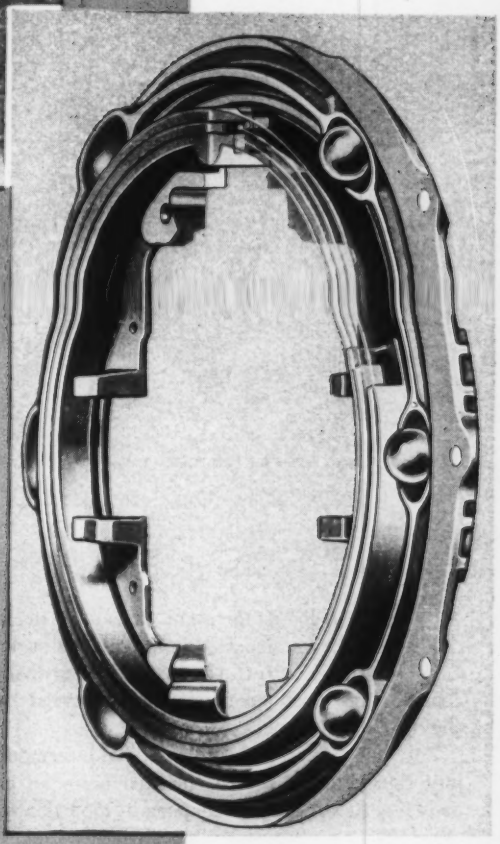
IDEAS

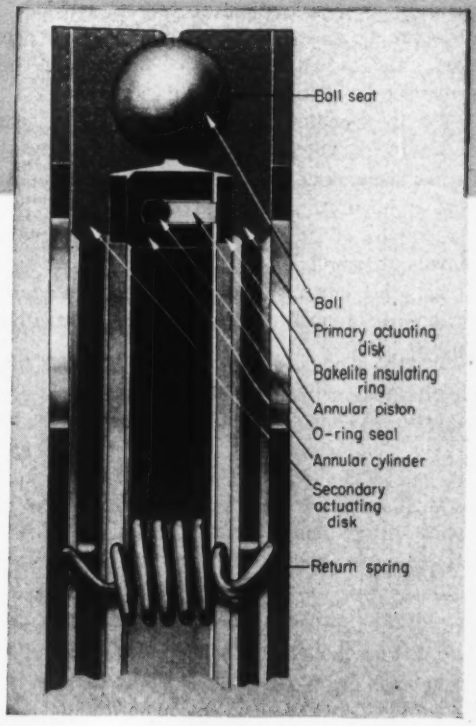


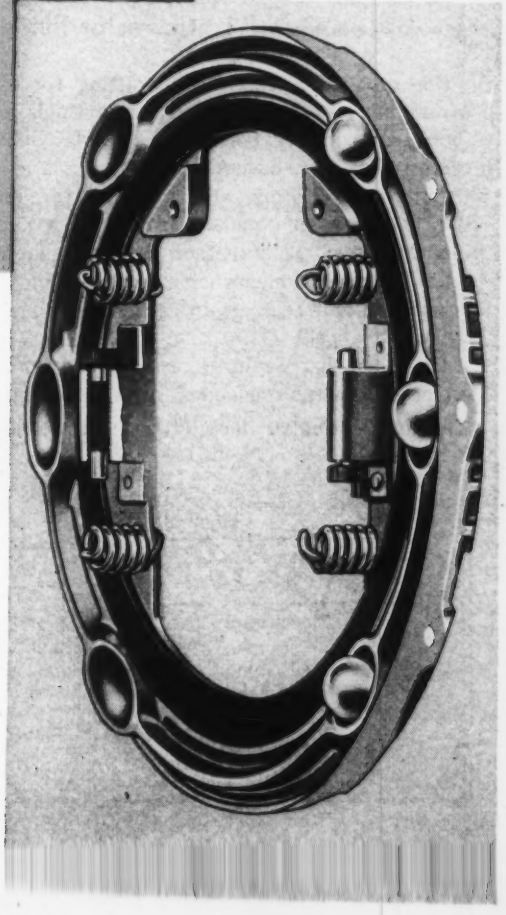


SELF-ENERGIZING DISK BRAKE for automotive applications utilizes vehicle momentum to assist brake action. Developed by Auto Specialties Mfg. Co. Inc., the design may be modified to energize in the forward direction only or in both directions.

Basic elements of the brake actuating assembly are an annular piston and cylinder plus six spherical balls positioned in seats cast in a pair of mating primary and secondary actuating disks. Braking action is initiated when hydraulic fluid under pressure enters the annular piston-and-cylinder assembly chamber. This fluid moves the O-ring seal against the annular piston forcing the two actuating disks apart. When brake lining on the disks then contacts friction surfaces on the brake housing, vehicle momentum acts to turn the primary actuating disk relative to the secondary actuating disk. This action causes the balls to roll up inclined ramps of the ball seats and forces the actuating disks farther apart, creating additional normal force at the braking surface.







11 tips How To Save

VALUABLE original drawings often cannot, or at least should not, be altered or modified. Yet tracing or redrawing are costly. This problem can often be solved through the use of intermediate copies.

For purposes of definition, an intermediate is any reproduction master printed from an original drawing in order (1) to permit modification and (2) to serve as a source of print-making.

This article shows 11 ways intermediates can be used to cut drafting hours. In some cases, depending upon the original and the work involved, various combinations of these 11 techniques can be applied to obtain best results.

The sample illustrations apply to various print-making methods such as moist-developed process, ammonia process, blue print, sepia negative, and even reproduction cloths in some instances.

In addition to drafting room use, these short cuts can be adapted for business and office systems to effect substantial savings in the preparation of originals and in reproduction operations.

1. Corrector fluids for small or scattered areas

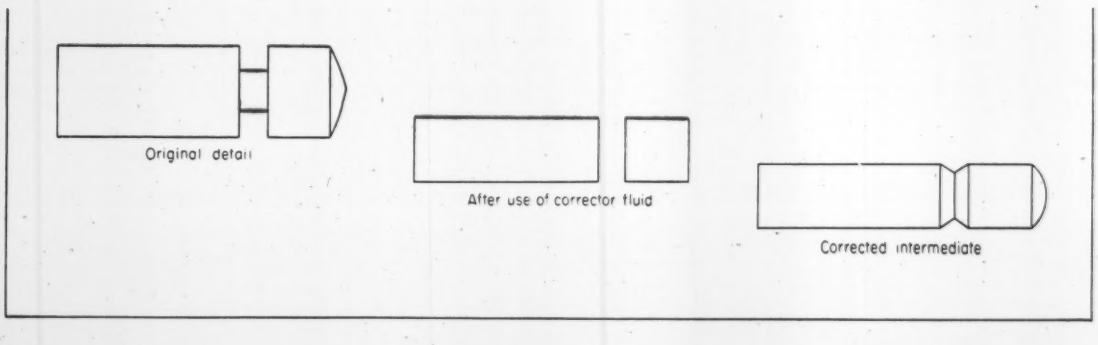
One of the most common drafting room time-savers involves the use of corrector fluids, rather than redrawing or tracing an original on which corrected data are desired.

Liquid eradicators are available for making line deletions on standard prints, as well as on intermediates. This method is well adapted to alteration of drawings when a portion of the details is obsolete or when certain details and dimensions must be changed.

Drawings that require alteration are reproduced directly from the unchanged original on an intermediate. Unwanted lines on the intermediate are removed by application of corrector fluid. New data are than drawn or lettered in the corrected area. The desired number of prints can then be processed from the corrected intermediate.

The intermediate is now a new master, capable of producing copies of the revised drawing at any future time. The original master drawing can be kept on file in its unchanged form.

Corrector fluid is recommended for image removal of small or scattered areas. For larger areas, the editing and masking techniques described in following sections are generally preferred.



Drafting Time

By Harry C. Goetz
Division Manager, Frederick Post Co., Chicago

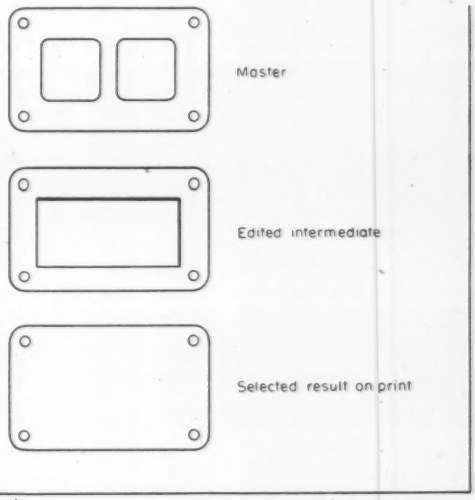
2. Scissors editing of large areas

When an original is to be modified, an intermediate print is made. The intermediate is then adapted by scissors-editing.

Undesired portions of the intermediate are cut out with scissors or blade. The edited intermediate can then be reproduced without any trace of corrections on the finished prints.

This intermediate application is most useful when large sections are to be removed. If additions are desired in the cut-out section, another intermediate is made directly from the scissors-edited intermediate, and new data are placed on this second intermediate.

In a diazo intermediate, a little background (under-exposure) is advisable since this will improve the intensity of the lines on the resulting prints. Print quality naturally is slightly reduced with each successive intermediate that is made.



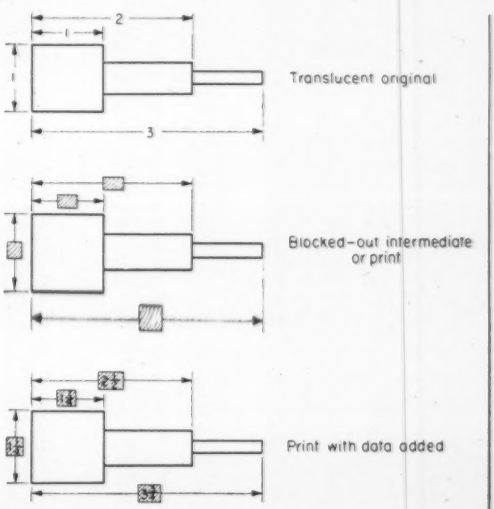
3. Blocking-out to delete small areas

Sections of an intermediate print that are too small to be cut away easily can be blocked out. Ink, pencil, or any other opaquing material can be used over the area to be deleted.

The corrected portion will appear as a dark image on the finished diazo positive print. This is a particularly suitable application of the intermediate technique, since it is usually not desirable to insert a blocked-out section on the original drawing.

When new dimensions or other data are required over the blocked-out area, they can often be inserted by means of colored pencil or ink. However, the block-out method is used primarily to remove obsolete matter.

When time is particularly important, the block-out technique is suggested for quick, on-the-spot alterations. Other methods discussed here obviously produce better-looking prints.



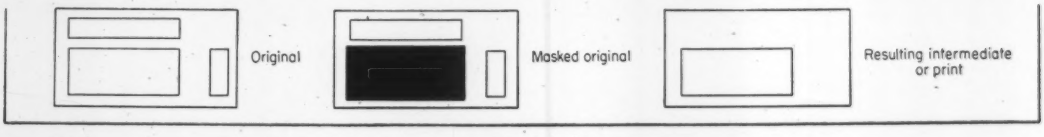
4. Masking for selecting or deleting large areas

The masking technique is based on the reproduction principle that the sensitized surface on diazo papers can be burned out by ultra-violet light in the printing machine.

If portions of the sensitized sheet are covered by an opaque mask and then fed through the printer light source only, the sensitized paper in the areas that are not covered will be burned out. Then, when the mask is removed and the print is made (exposed and developed) in the normal manner, those portions of the original which are over the burned-out areas of the sensitized paper will not be reproduced. Regardless of the shape of the sections to be deleted, a mask can be designed to insure reproduction of the selected parts only.

This masking procedure can be followed in making prints from a selected area on an original, or in making an intermediate to be used as a print-making master, whether additions are desired in the selected area or not.

The sequence of operations is: (1) Cut out a mask with opaque paper; (2) place mask over sensitized paper and feed through the light source section only; (3) follow normal printing and developing procedure with the original, but without the mask.



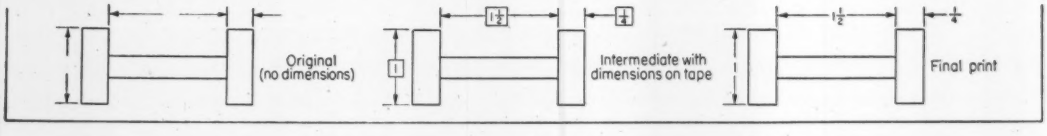
5. Transparent matte tape for adding variable data

With its matte surface on one side and adhesive on the other, transparent mending tape can be used for many time-saving applications other than mending.

This tape is functionally an intermediate which can take dimensions drawn on the matte surface. It can be applied to paper, cloth or film, and becomes an integral part of any original or intermediate.

Many engineering departments have standard unit drawings with identical design, except for variable dimensions. One master drawing without dimensions can be used to produce a complete file of standard units by means of intermediates with the dimensions added, as needed, via the transparent matte tape method.

As a job order is received, dimensions, symbols and other engineering variables can be applied by tape additions for the particular data desired without the necessity of complete redrawing.



6. Nonreproducible blue for master records

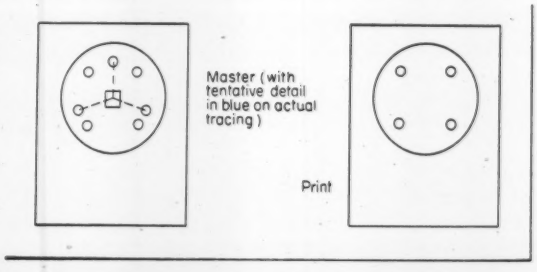
Certain shades of blue and violet do not block ultra-violet light. As a consequence, with most copying processes such lines will not print.

Detailed entries on drawings or records when made with nonreproducible materials will not appear on the prints. For example, this is used in business systems to prevent confidential data from appearing on finished copies intended for general distribution. It can also be used in cases where subject matter is necessary on both sides of a form, but facsimile copies are required of one side only.

Experimental layout work can be done on an original or on an intermediate. Yet, prints can be quickly made showing only the data that had been originally drawn.

The best nonreproducible line is sharp but light, in preference to broad heavy lines which normally will reproduce faintly. However, with the recent increased use of the "phantom-line" technique, there are several specially adapted materials available that provide high visual density, but will not show in reproduction.

A variety of phantom-line products on the market today are suitable for nonreproducible applications: printers ink, fountain pen ink, pencil and typewriter ribbons in addition to special pencils.



7. Successive additions with matte-surface film

This idea can be applied to engineering drawings, bills of material and parts lists. It can also save time in payroll, accounting and inventory procedures.

The constant data are printed on a film intermediate from a translucent original. Variable additions are then added to the film intermediate with pen and ink, typewriter or pencil. After prints have been made from the matte film, these additions are easily removed with a damp cloth, carbon tetrachloride, or eraser.

A succession of variable data can be recorded over and over, using the same diazo film intermediate because of its durability and the ease of making additions and deletions. This method may apply particularly to:

1. Procedures requiring an unchanging printed form to which variable entries are made and where copies of the completed forms are desired.
2. Questionnaires to be completed by the recipient, copies of which are desired on return to the distributing office.
3. Maintenance of lists subject to continuous addition.

Economy of this method on such jobs usually more than offsets the cost of matte film.

Time Report		Date: 12/15/55
Project	Est.	To Date
101 – Model A2	800	469
102 – Model C7	1000	1116
103 – Model F3	400	85

Constant data — Variable data

8. Pick-off transfer with matte tape

Use of transparent matte tape to transfer columns of figures can eliminate tedious transcription time and avoid the possibility of human error. This is a completely different method from the previous example.

The fourth column made on a diazo film intermediate in the accompanying illustration was originally blank. Note that the pencil entries in the second column have been transferred to the last column. This is done by (1) placing the adhesive side of the tape over the pencil figures in the second column, (2) removing the tape in order to pick-off the numeral impressions from the film, and (3) permanently placing the tape that bears the image of these numbers onto the last column. The resulting prints carry all data desired without lengthy entry work on original or intermediate, and the film intermediate can be changed later for other variable data.

When experimenting, allow a little extra tape to hold onto. Otherwise it will be difficult to lift up from the matte film. Then merely apply direct finger pressure over the applied tape to pick-off the desired data. It is also possible to pick-off certain data in pen or typewriter ink.

The pick-off transfer technique can also be applied to a high quality tracing medium that has the surface characteristics of translucent film.

Part No.	Qty. This Month	Est. Monthly Qty.	Qty. Last Month
2832	4683	5000	4683
2833	7814	7700	7814
2834	6381	6300	6381

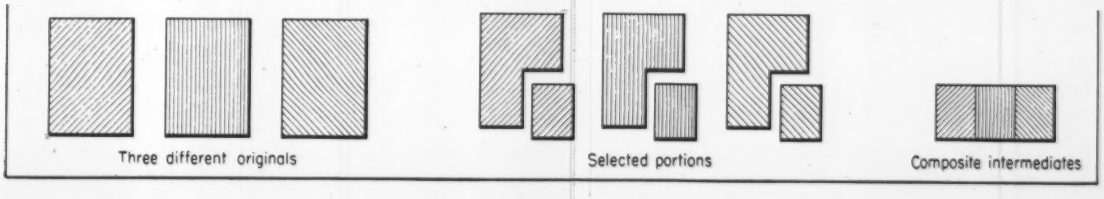
Picked-off and transferred

9. Composite grouping from several originals

The intermediate technique is especially useful and appropriate when several different drawings (or more often sections of the drawings) are desired on one reproduction master.

An intermediate is made from each original (or portion of original) involved, and the resulting intermediates are cut and formed to the locations wanted in the new overall pattern by the use of transparent mending tape.

Subsequent standard prints can then be processed without noticeable traces of the patching. If the details on the original drawings are sufficiently strong, another intermediate can be printed from the composite intermediates that have been taped, thus providing a reproduction master for subsequent print making.

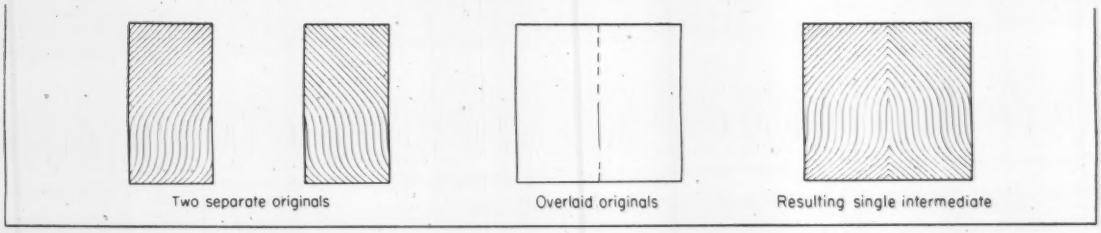


10. Composite overlays from several originals

Where two or three highly transparent original drawings are available from which data are to be combined into a single composite for future prints, a single master intermediate may be obtained without making separate intermediates.

The overlay method involves superimposing the two originals into the desired location (identical register is best if the design subjects permit). The overlayed originals are exposed on a sensitized intermediate, preferably a highly transparent one, and then developed to get the composite copy.

These methods often make it possible to combine valuable originals into a single master at little expense.

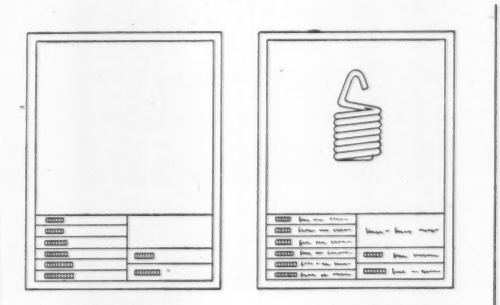


11. Preprinting of constant data

Frequently certain constant information may be used over and over—not only in forms, bills of material and parts lists, but also in drawings.

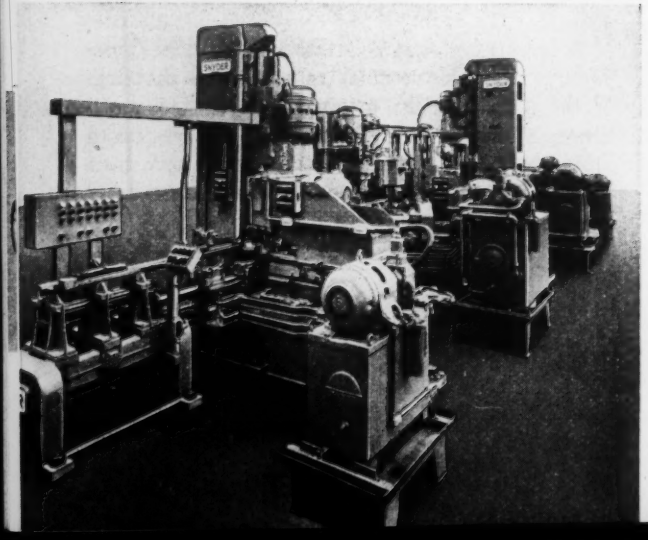
Under such conditions, consideration can be given to printing such data directly onto the sensitized surface of the diazo paper (or on the reverse side) by means of standard offset or letterpress printing. Sensitized materials can be printed in this manner, just as can regular commercial papers, with no harm to the chemical emulsions on the sensitized surface.

In subsequent print making, the preprinted image will obviously appear very satisfactorily on the resulting print, as will the detail added to the master.



Contemporary Design

Twisted Rail Eliminates Orienting Devices in Transfer Machine



A NEW segmented transfer machine uses a twisted slide rail arrangement to move and orient automotive-engine exhaust manifolds. The 20-station, 43-ft long machine performs all machining operations on the cast-iron manifolds except for grinding the mounting faces. Two bushings and two pins are also assembled to the manifold by the machine which produces 106 manifolds per hour at 75 per cent efficiency. In-process gaging devices are also incorporated in the machine made by Snyder Tool and Engineering Co.

In this machine, manifolds are loaded on the slide rail on the ground faces and pushed from station to station on the rail. Any twisting or tilting of the parts to position them properly for a particular operation is achieved by twists in the rail.

Designing

Sliding Gears

to Stay in Engagement

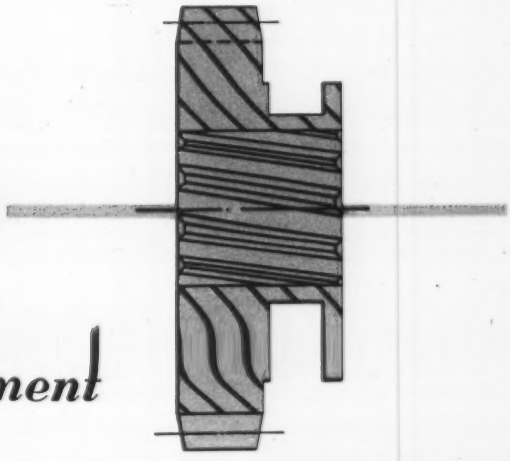


Fig. 1 — Original design of sliding gear has helical teeth and shifts on a helical spline

By Herbert H. Alvord
Assistant Professor of Machine Design
University of Michigan
Ann Arbor, Mich.

SHIFTING a sliding gear on a splined shaft is a simple and effective method of obtaining speed change in many power-transmitting devices. If not properly designed, however, the sliding gear will often work its way out of engagement while operating under load.

If this occurs with a helical gear mounted on helical splines, it is commonly blamed on the helix angles not completely balancing out the thrust. In the majority of cases, however, the helix angle has very little, if anything, to do with it. This is borne out by the fact that sliding spur gears on straight splines have the same tendency.

Original design of a sliding gear used in an auxiliary truck transmission is shown in *Fig.* 1. This gear had helical teeth, and shifted on a helical spline. Design of the transmission was such that several variations of the same transmission were available. It was found that with certain assemblies no trouble was encountered, while with other assemblies, this gear would slowly work its way out of engagement while under load.

Analysis showed that the combined tangential and radial components of force on the gear teeth caused the gear to tilt on the splined shaft as shown in *Fig.* 2. This tilting resulted from the gear teeth, and hence the gear tooth forces, being located at one end of the piece, rather than in the center. Clearance at the spline then permitted the

Fig. 2—Tilting of gear on splined shaft is caused by forces on gear teeth located at one end of piece

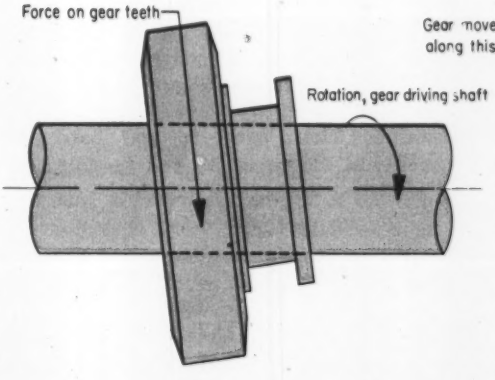
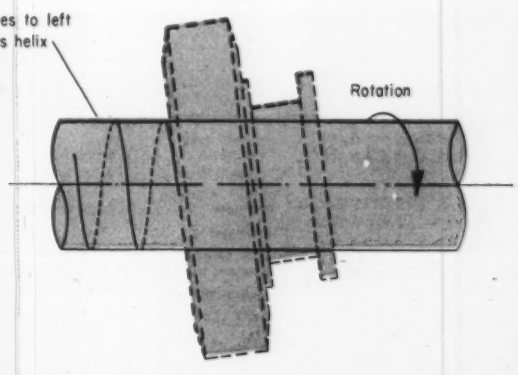


Fig. 3—Gear tends to move along shaft while rotating under load



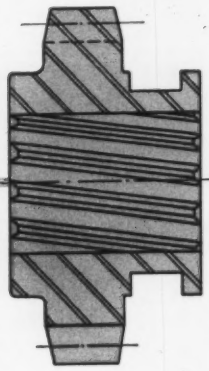


Fig. 4—Improved design of sliding gear has added hub which locates teeth more centrally and reduces tendency of gear to tilt on shaft

gear to run at an angle to the shaft.

The gear contacted the shaft at the ends of the gear, and because the gear was tilted, the line of contact between gear and shaft formed an angle with the shaft like that of a fine screw thread. As the shaft and gear rotated, the gear tilted continuously. In this way the gear in effect rolled backward on the shaft, at the same time moving axially along the thread-like helix formed at the gear and shaft contacts. Thus, the gear moved slowly but persistently out of engagement, as shown in Fig. 3.

With the rotation shown in *Figs.* 2 and 3, and with the gear driving the shaft, the gear moves along the shaft to the left. If, with this same rotation, the shaft were driving the gear, the gear would tilt to the opposite side, and would then move along the shaft to the right. It is therefore quite easy to predict which way the gear will tend to travel while in operation.

If the assembly contains a bearing or some other object immediately adjacent to the gear on the end toward which the gear tries to travel, the gear will stay in position. This accounts for the fact that with some assemblies of the transmission the gear shifted out, while with other assemblies it stayed in engagement.

Subsequent testing proved the validity of this analysis and showed that this action was entirely independent of the helix angles.

The design was corrected by adding a hub to the sliding gear as shown in *Fig.* 4 so as to have the gear teeth more centrally located, thus greatly reducing the tendency for the gear to tilt on the shaft. At the same time, the manufacturing tolerances were changed to insure a good minor diameter fit on the splines. A third change consisted of increasing the radial thickness of the material at the shift collar to reduce warping of the splines during the heat treating operation. After these changes, there was no further trouble.

From the foregoing, it appears that these simple rules should be followed when designing sliding gears:

1. Locate the gear teeth as centrally as possible along the length of the piece.
2. Provide a good major diameter or minor diameter fit on the splines.

In this way, trouble due to gears working out of engagement can be eliminated.

Comparing Cost of Aluminum Finishes

COST is an important factor in specifying surface finish for aluminum parts. Relatively inexpensive parts generally would not carry expensive surface finishes. There are exceptions, however. Equipment for outdoor service requiring long life and an attractive appearance will warrant a more expensive finish.

Comparative cost figures of various aluminum surface finishes have been compiled by Reynolds Metals Co. The accompanying table lists a range of estimated total costs based on continuous production operations.

Lowest cost given is for processing large flat panels in high production automatic equipment. Costs for processing smaller pieces in hand-operated equipment of moderate size are represented by the high figure. These estimated costs are said to include labor, overhead and burden; maintenance and depreciation; and heating, chemical and electrical costs, if applicable.

Typical Costs of Finishing Aluminum

Finish	Cost (Dollars per sq ft)	Finish	Cost (Dollars per sq ft)
Mechanical		**Electrolytic Oxide**	
Polishing	0.020-0.100	Chromic acid process	0.150-0.300
Scratch brushing	0.010-0.050	Sulphuric acid process	0.100-0.250
Satin finishing	0.010-0.050	Electropolishing	0.200-0.500
Chemical		Coloring anodic coatings	0.030-0.060
Caustic etch	0.010-0.020	**Electroplated**	
Alrok process	0.020-0.040	Copper plating	0.200-0.400
Alodine process	0.015-0.030	Chromium plating	0.300-0.500
Bonderite 170 process	0.015-0.030	**Cleaning Treatments**	
Phosphatizing	0.010-0.020	Solvent	0.0025-0.010
Zincate coating	0.040-0.080	Alkaline	0.0025-0.010
Organic		Acid	0.005-0.015
Chemical treatment and paint	0.020-0.080	Precleaning for resistance welding (chemical)	0.010-0.020

"In electronic terms, the human brain is the equivalent of a billion trillion vacuum tubes. Compared with that, as someone has observed, our best computer is still a low-grade moron."—DR. DEAN E. WOOLDRIDGE, *president, Ramo-Wooldridge Corp.*

Germanium Power Rectifiers

An Up-to-Date Progress Report on

- Available Types
- Electrical Characteristics
- Operating Characteristics
- Cooling Methods
- Applications

By G. B. Farnsworth and S. P. Jackson

Rectifier Dept.
General Electric Co.
West Lynn, Mass.

GERMANIUM power rectifiers have in a little over three years emerged from the research laboratory into the forefront of the power rectifier field. A partial explanation of this rapid development lies in the fact that of the three types of power rectifiers in general use today—germanium, selenium, and copper oxide—the theory of operation of germanium is best known. Also, of the three, germanium rectifier manufacturing techniques are easiest to control. Basic characteristics of germanium power rectifiers are discussed here to provide designers useful information for applying these units.

Germanium Characteristics: Germanium is a metallic element of the silicon group lying between silicon and tin in the periodic chart. It is a gray-white, crystalline, brittle metal that retains its luster in air at room temperature. Germanium is prepared by reducing the oxide obtained from silver and zinc ores with carbon or hydrogen. This metal melts at 958 C, vaporizes at 1350 C and has a specific gravity of 5.47.

Cell Construction: A "sandwich" formed by germanium and appropriate impurities on either side to form P type and N type comprise a germanium rectifier. To this is attached a suitable "package" to provide terminals, eliminate strains and provide a means for dissipating the heat generated. A cutaway view of a germanium rectifier is shown in *Fig.* 1.

It is sometimes desirable to protect the rectifier from the effects of its environment. For these applications the package must also include a means of hermetic sealing. In *Fig.* 2 are two types of component germanium rectifiers: a resin-potted cell and a hermetically sealed cell.

Electrical Characteristics: A comparison of volt-ampere characteristics of a germanium rectifier with those of selenium and copper-oxide rectifiers is made in *Fig.* 3. Note that the forward current scale for germanium is 1000 times that for the other two materials. Also, in regard to the forward characteristics of the three cells, germanium has a lower voltage drop per ampere than either of the other two. To the designer this character-

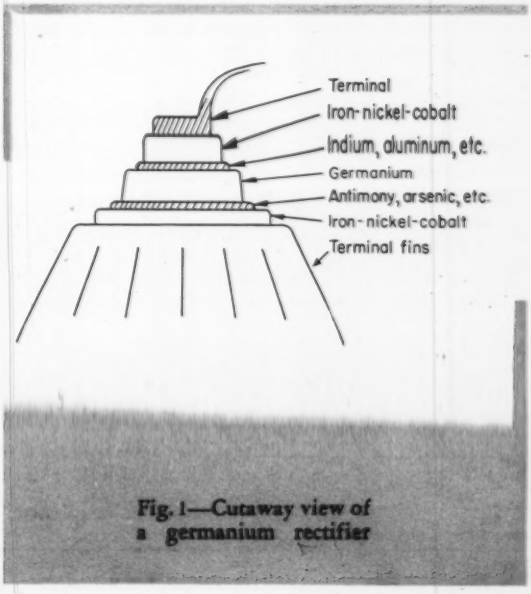


Fig. 1—Cutaway view of a germanium rectifier

istic means that the efficiency of the germanium cell is high.

Comparative efficiencies of four types of metallic rectifiers are shown in *Fig.* 4. Since the curves shown are for a single-phase full-wave bridge type rectifier, the average voltage of the output wave form is not equal to the rms voltage of the input wave form. Thus, the theoretical perfect conversion efficiency is not 100%. It can be seen that germanium closely approaches the theoretical perfect efficiency line.

Since the forward voltage drop of germanium rectifiers is extremely small, regulation is good, *Fig.* 5. It should also be noted in *Fig.* 4 that the germanium rectifier has much lower leakage current than either of the other two. Thus, reverse losses are very low.

A size comparison between germanium and selenium rectifiers on the basis of equivalent capacity is made in *Fig.* 6. Obviously, germanium permits the design of a smaller power rectifying unit. While this comparison of cells of the same capacity shows the germanium type to be much smaller, this difference is not as great in complete power supplies.

It has been found that germanium rectifier cells may be operated in either series or parallel as is common practice with both the selenium and copper oxide types provided proper precautions are taken in grading and selecting the cells.

Germanium possesses none of the characteristic increase in forward resistance that both selenium and copper oxide exhibit to varying degrees. Selenium ages because the chemical reaction within the cell at room temperature is appreciable. Also, diffusion processes in selenium change the original constitution. In the case of copper oxide, these reaction processes tend to slow down and stabilize in time and it is therefore more stable than selenium. In germanium the impurities are held down more rigidly in their position and, therefore, there is no noticeable trend in any of the characteristics of germanium which might be called aging. Life

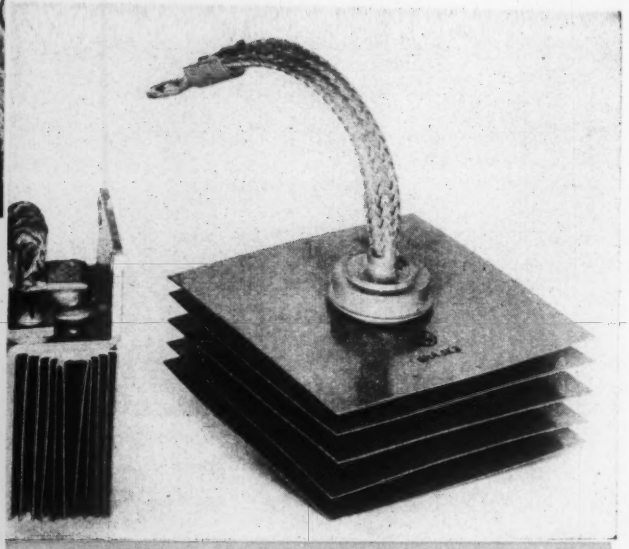


Fig. 2—Two types of component germanium rectifiers: a 9/16-inch resin-potted cell mounted on a fin assembly which has a rating of 75 amperes with proper blower cooling (left) and a 9/16-inch hermetically sealed cell mounted on a five-plate assembly which handle more than 100 amperes with proper fan cooling

Fig. 3—Comparison of volt-ampere characteristics of germanium, selenium and copper-oxide rectifiers. Current density is based on 1 square centimeter of active area

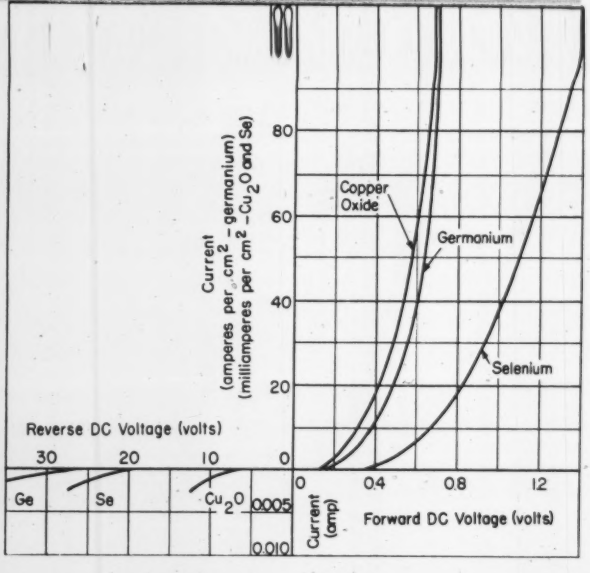
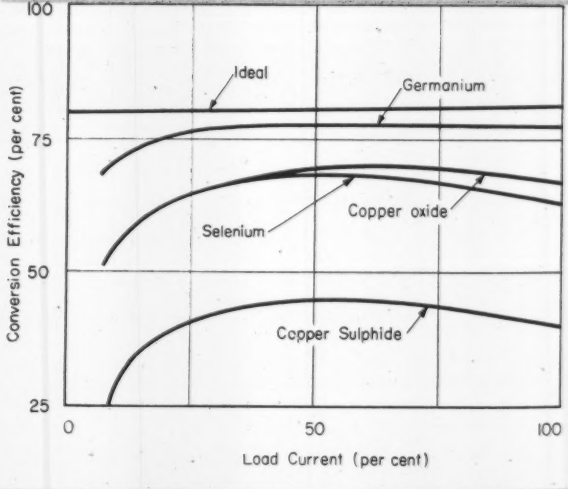


Fig. 4—Curves of ac-to-dc conversion efficiencies of four types of metallic rectifiers based on a single-phase full-wave bridge type circuit



tests of more than three years have verified the theory on this point.

Germanium cells exhibit a characteristic which is in common with many electrical devices; it is subject to dielectric breakdown at very high voltage. In applying germanium rectifiers in design as with other types it is necessary to provide protection against voltage surges. If the surge exists for a short duration, a clipping circuit, a nonlinear resistor, or a capacitor may be used to limit the amount of peak voltage. Where voltage surges over a comparatively long period of time are experienced, such as regenerative loads sometimes encountered in crane and elevator applications, a relay and absorbing resistor may prove successful in limiting the amount of voltage applied to the cells. As yet a commercial device of this type is not available due to the difficulty in obtaining fast enough response to protect against the rising voltage. However, it is expected that such a device will be available soon. The steepness of the transient wave front and the amount of energy in the transient determine the method to be used.

The ability of the germanium cells to withstand dielectric breakdown decreases with temperature increase. Thus, the voltage rating of a given cell must decrease with increased temperature. Under current overload conditions, the cell may be heated to a high enough temperature level to cause failure either from dielectric breakdown or from the melting of the cell components. *Fig.* 7 is a plot of overload current to the cell versus time to fail. The overload current is plotted on the basis of a single-phase half-wave rectifier, and values must be changed if used in a different circuit.

Another quirk of the germanium cells should be noted. For the cell to change from a very low resistance in the forward direction to a very high resistance in the reverse direction, a change must take place within the cell. This change requires a small amount of time. For most power applications, this effect may be neglected. Immediately upon a change of the applied voltage from forward to reverse, the resistance of the cell is low—approximately equal to the forward resistance. The peak current flow—sweep-out current—is approximately equal to the forward current. As the cell recovers its ability to block, the current decay roughly follows an exponential.

Cooling: Forced air may be used to cool germanium power rectifiers. This method is inexpensive, but where clean air is available with ambients not higher than 40 C it is the simplest way to cool germanium rectifiers.

If water is available to use for cooling the cells, it usually has a lower ambient temperature than air. Therefore, it is possible to cool the cells more efficiently and to increase power ratings by this method. One way of cooling germanium cells through the use of liquid is shown in *Fig.* 8. The cells are mounted in a tank through which a coolant is pumped. This is passed through the water to a coolant heat exchanger at the far right where the heat is removed from the coolant which is then recirculated through the tank. As shown in *Fig.* 8, several tanks can be cooled using one pump and one heat exchanger by connecting their coolant flow in series. Full power ratings can be obtained at water temperatures up to 86 F.

Fig. 5—Regulation curves of germanium cells in a 6-1-1 bridge circuit

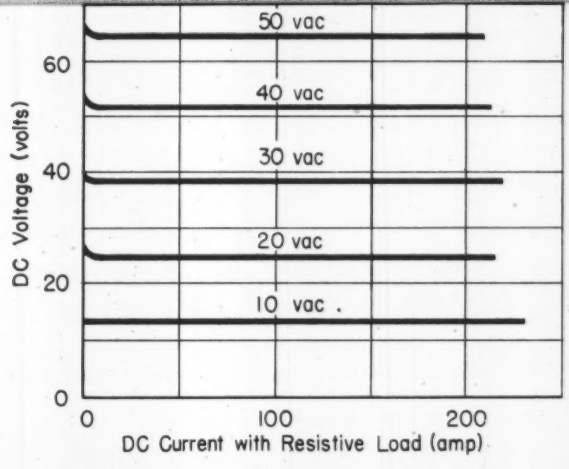
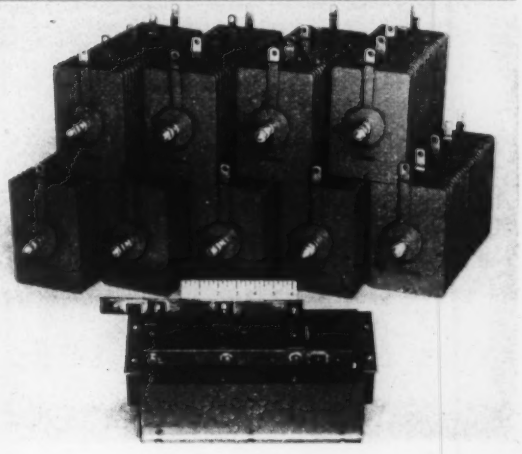


Fig. 6—Comparison of size of selenium and germanium rectifiers of equivalent capacity. Both are rated at 18 kilowatts



Applications: As the characteristics discussed should indicate, practical applications of the germanium power rectifier spread across the entire field of conversion equipment. *Fig.* 9 indicates how large a segment is within its range; while this chart does not show germanium used above 150 volts, this is not an inherent voltage limit but rather the approximate level where other types of conversion equipment approach germanium efficiency and have lower first cost. Of course, improvements in germanium voltage capabilities are expected which will permit lower costs outside the range indicated in *Fig.* 9.

Since tube type rectifiers have higher voltage capabilities inherently, their cost increases as the operating voltage comes down. To a somewhat less extent the same is true of mechanical rectifiers. Obviously, it is desirable to design for a specific application, thus utilizing to the maximum the characteristics of germanium which are of greatest importance to that application while designing around undesirable operating conditions where they are known to exist. An analysis of designs for several applications will serve to illustrate these facts and indicate the fields in which germanium is being successfully applied today.

One important area of application of the germanium power rectifier is in electrochemical and metallurgical process lines. Germanium rectifiers provide efficient, reliable conversion equipment to operate on low voltage for hydrogen and chlorine production, copper refining, and many other processes. With a germanium power supply available with an overall operating efficiency above 85 per cent at 12 volts and on the order of 95 per cent at 75 to 150 volts, a dc voltage can be chosen to suit the load requirements. Power costs can often be kept as low as for much higher dc voltage lines using other ac-to-dc conversion means. Ger-

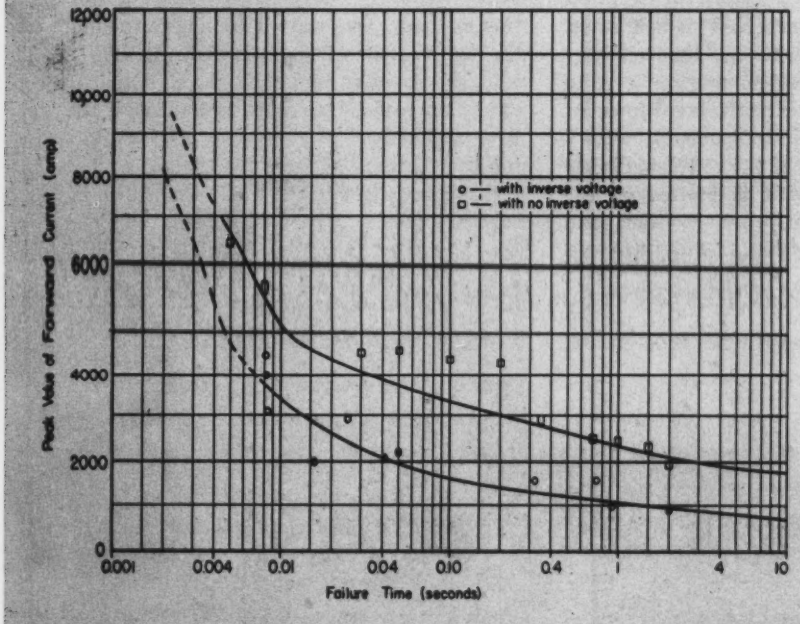
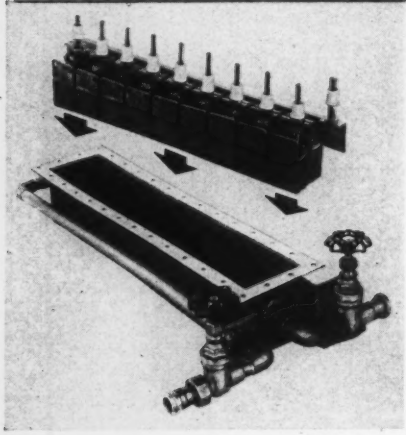
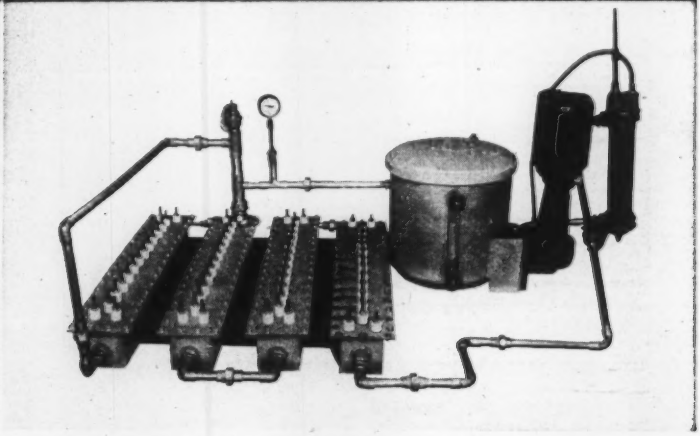


Fig. 7—Left—Plot of peak values of forward overload current versus failure time for germanium cells based on a single-phase half-wave rectifier circuit using 9/16-inch diameter cells

Fig. 8—Below—Liquid coolant system for germanium rectifiers consisting of a circulating pump, a heat exchanger and germanium trays and tanks connected in series





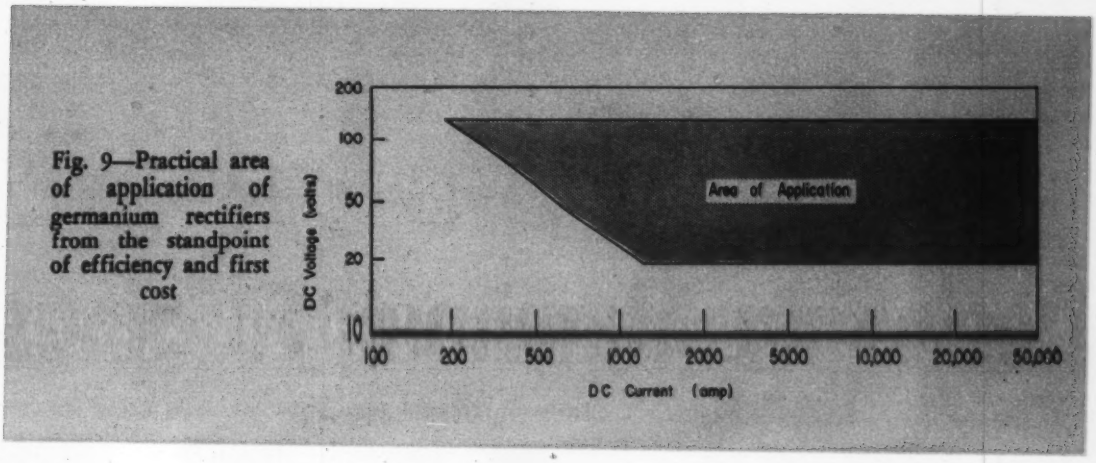


Fig. 9—Practical area of application of germanium rectifiers from the standpoint of efficiency and first cost

manium power supplies rated at 65 volts, 16,000 amperes dc have been installed for hydrogen production.

The same design and application considerations are valid when using germanium power supplies in the electrofinishing. Although voltages are generally below 50 volts, the design of the equipment is almost the same as for the electrochemical equipment. A germanium-rectifier installation rated at 24 volts, 40,000 amperes dc, has been installed for continuous anodizing service.

Another application of germanium is for supplying 2000 amperes of dc power for electric arc furnaces used in titanium reduction and purification. Here, a drooping voltage characteristic with an open-circuit voltage of 80 volts and a full-load voltage of 40 volts is required.

Germanium rectifiers used as ac-to-dc conversion elements in dc arc welders show distinct advantages in size, power cost, and component cost savings when compared to other types. However, the use of germanium rectifiers in this application does introduce a condition which, if not considered, can be troublesome. When the dc circuit is interrupted rapidly, the induced voltage in the transformer is proportional to the inductance of the total circuit multiplied by the time rate of change of the current. Therefore, if the inductance is high, as it is in this case, and the change in current is rapid, as it might be if the arc is lost, secondary voltage of the transformer applied to the rectifier might be quite high. Transient voltage "spikes" experienced under these conditions might damage the germanium cells unless limited to a lower value. As previously mentioned, there are several ways of doing this. One method is to add a capacitor to the circuit to absorb this energy and limit the voltage to a safe value.

Galvanic Couple Corrosion Data for Titanium with other Metals

IN using titanium in conjunction with other structural engineering materials, both may be subject to corrosion by sea water or sea air. According to a report by Rem-Cru Titanium Inc., coupling of titanium with another metal in a marine atmosphere does not increase the corrosion rate of titanium. However, titanium has been found to effect the less noble metals in much the same way as type 18-8 stainless steel.

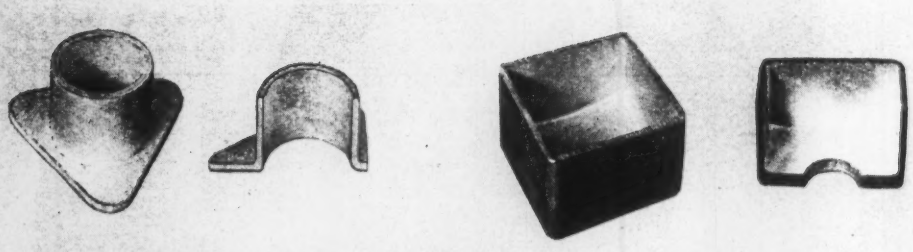
Results of recent tests (see table) conducted by International Nickel Co. indicate that stainless steel may be coupled with titanium with no increase in corrosion rate of either metal. Magnesium, aluminum and copper-base alloys however, should be insulated from adjoining titanium parts if galvanic corrosion of these alloys is to be minimized.

Tests were conducted where other metals were coupled to titanium in areas of a ratio of 1:7 (titanium couple seven times the area of the other metal). When the relative areas were reversed, the corrosion rate for the other metal in the couple was considerably lower than that observed where the area of titanium was greater.

Corrosion Rate of Metals Coupled with Titanium*

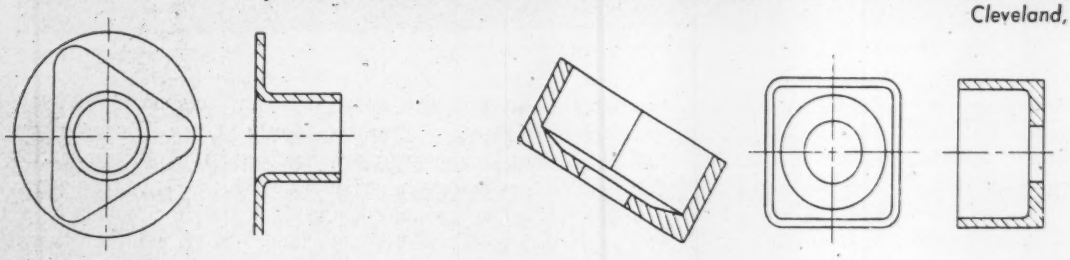
Material	Sea Water (per cent)	Sea Air (per cent)
Magnesium, AZ31	150	400
Aluminum, Alclad 2024S-T3	300	500
Aluminum, 5052S, ½-hard	1000	100
Aluminum, Alclad 7075S-T6	500	750
Copper	350	300
Steel (low carbon)	150	...
Monel	180	200
Inconel	100	100
Stainless steel, Type 302	100	100
Stainless steel, Type 316	100	100
Silver	170	...

*Normal corrosion of the metal by itself is given as 100 per cent.



Designing Aluminum Forgings

By A. E. Favre, *Chief Production Engineer, Forging Div., Aluminum Co. of America*
Cleveland, O.



RECENT advances in the forging of light metals have made a distinct improvement in the tolerances available to the designer. New aluminum forging alloys extend the properties of aluminum forgings in certain valuable respects. Operation of the giant forging presses under the U. S. Air Force Heavy Press Program has appreciably increased the size of aluminum forgings now available.

Design changes that these advances in process, press equipment and alloys will make possible are of extreme value to designer. Considerable improvement in the dimensional tolerances of light-metal forgings, much smaller draft angles, better physical properties in thick sections, as well as thinner webs and ribs than were heretofore possible can be expected.

Press size increases will allow aluminum forgings to be produced inside a working die area as large as 10 by 23 ft. Size of forging produced in these huge presses is not limited by the die area alone, however. Pressure required to fill a forging die of a particular size and shape restricts the size of that forging even on these large presses capable of applying up to 50,000 tons pressure. An exact evaluation of the effect of these presses

Table 1—Mechanical Properties of Aluminum Forging Alloys[1]

Alloy Number	2014-T4	2014-T6	6151-T6	7075-T6	4032-T6	2218-T72	2018-T61	6061-T6	2025-T6
Minimum Specification Values[2]									
Tensile strength, psi	55,000	65,000	44,000	75,000	52,000	38,000	55,000	38,000	55,000
Yield Strength, psi (Offset=0.2%)	30,000	55,000	37,000	65,000	42,000	29,000	40,000	35,000	33,000
Elongation, per cent in 2 inches	16	10	14	10	5	8	10	10	16
Brinell hardness (500-kg load, 10-mm ball)	100	125	90	135	115	90	100	80	100
Typical Values									
Tensile strength, psi	62,000	70,000	48,000	82,000	55,000	46,000	62,000	45,000	58,000
Yield strength, psi (Offset=0.2%)	44,000	60,000	43,000	72,000	46,000	36,000	48,000	40,000	37,000
Elongation, per cent in 2 inches	20	13	17	11	9	10	12	17	19
Endurance limit,[3] psi	18,000	18,000	11,000	21,000	16,000	.....	17,000	13,500	18,000
Shearing strength, psi	38,000	42,000	32,000	49,000	38,000	.....	39,000	30,000	35,000
Brinell hardness (500-kg load, 10-mm ball)	105	135	100	150	120	90	120	95	110
Modulus of elasticity, psi $\times 10^{-6}$	10.6	10.6	10.2	10.4	11.4	.....	10.8	10.0	10.4
Weight, lb/in.^{3}	0.101	0.101	0.097	0.101	0.097	0.099	0.101	0.098	0.101

[1] Other data (all alloys): Modulus of rigidity=3.85×10^6 psi; Poisson's ratio=0.33. Compression strength is equal to or greater than tensile strength. Bearing strength equals 1.8 times tensile strength, provided edge distance of hole is not less than twice its diameter.
[2] For forged sections to 4 in. thick (3 in. for 7075-T6). Based on standard half-inch diameter test specimen with axis parallel to grain flow.
[3] Based on 5×10^8 cycles of completely reversed stress using R.R. Moore type machine and specimen.

Alloy Selection
Draft Angles
Fillet Radii
Parting Line Location
Tolerances

on aluminum forging design must wait on operating experience. Until that time, the existing design information based on experience with presses in the 15,000 to 20,000 ton class should serve as a helpful guide.

Alloy Selection: The principal reason aluminum forgings are used in preference to other engineered parts lies in the superior mechanical properties they offer. Toughness and directional properties are highly developed by the forging process. The tough, fibrous directional character of the stock may be shaped to conform to the outlines of the forging and so permit the principal loads in the most favorable grain direction.

Typical tensile strengths are as high as 82,000 psi, and yield strengths may be over 70,000 psi. Strength of a forging depends greatly, of course, on the alloy used, *Table* 1. Correct design is also necessary to provide the maximum properties in a forging at a minimum cost.

In addition to affecting the mechanical properties of a forging, the alloys used also affect the forgeability or ease with which the part can be made, *Fig.* 1. Alloy 2014 is the most widely used of the high-strength aluminum forging alloys and is recommended for general structural applications. This alloy provides high tensile strength, high yield strength, hardness, good ductility, good resistance to fatigue, and good resistance to corrosion. Alloy 2014 also has reasonably good forging qualities, and it is readily machinable.

Alloy 6151 surpasses all other commercial al-

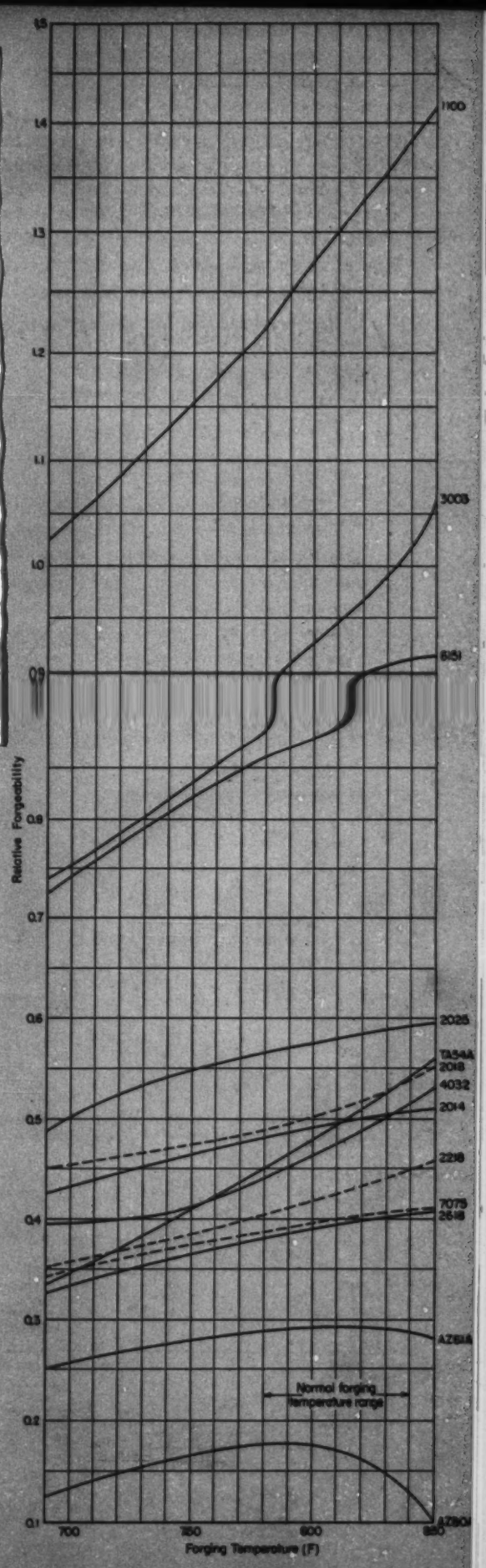


Fig. 1 — Relative forgeability of aluminum and several magnesium alloys

loys in forgeability, and its machining characteristics are excellent. These production advantages are combined with moderately good mechanical properties and excellent resistance to corrosion. Products whose service does not demand extremely high strength, but which must be produced in quantity at low cost, are ideal applications. Alloy 6151 is recommended for ordinary commercial forgings.

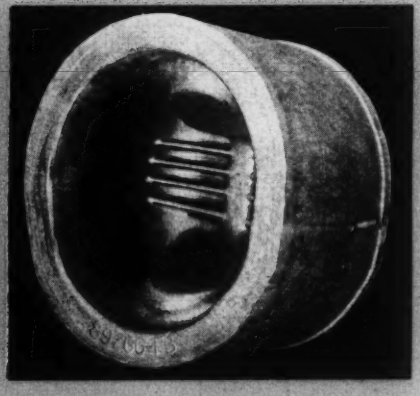
Alloy 7075 is a superstrength aluminum forging alloy. It is less easily worked than the other alloys, however, and forgings in 7075 are generally more expensive. Selection and inspection of the stock, blocking or preshaping, finishing, and heat treating all require close control. Care in forging designs to eliminate forging difficulties and to promote reasonable die life is very important with this alloy. Alloy 7075 is specified where the highest mechanical properties obtainable in an aluminum forging are deemed necessary and where the performance of the part justifies some extra manufacturing expense.

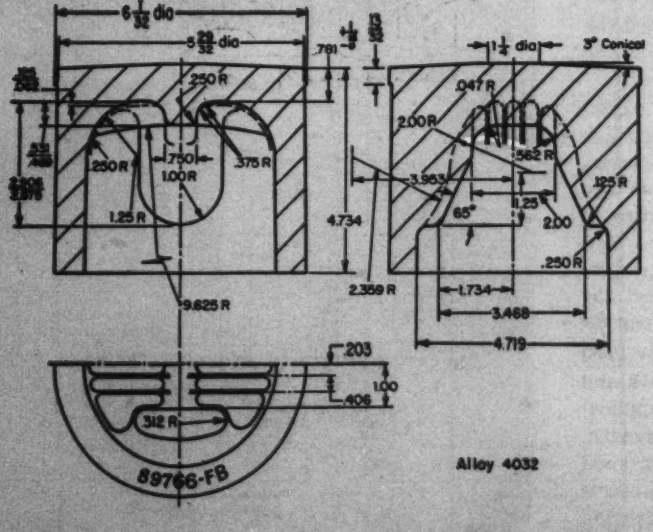
Alloy X7079 is a newcomer to the aluminum forging alloy family. It joins 7075 in the superstrength category. Alloy X7079 offers greatly

RECENT advances in aluminum forging have resulted in a special, elite class of forgings, generally referred to as precision forgings. These parts offer a finished forging that in some cases may completely eliminate machining operations.

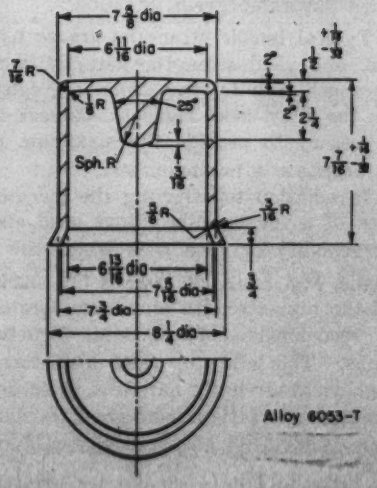
By exacting control of the forging operation very close tolerances can be met. Draft angles can be held to zero degrees, and the design proportions between the thickness of forging webs and ribs can be reduced beyond the 25 to 50 per cent reduction now possible with standard aluminum press forgings.

Die and piece prices on precision forgings are naturally higher because of the closely con-





Alloy 4032

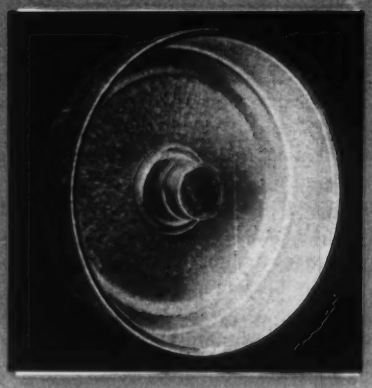


Alloy 6053-T

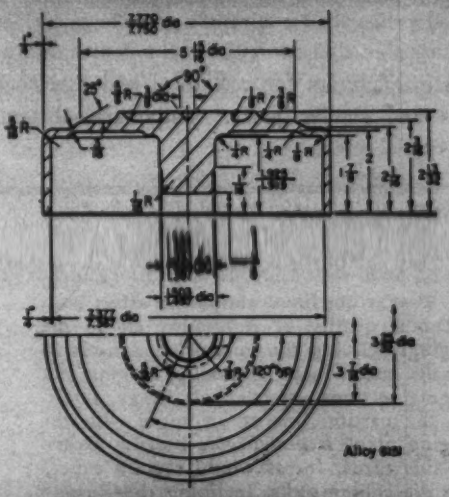
improved ductility in the transverse direction, with little or no reduction in longitudinal properties. In addition, it may be quenched in much thicker sections than 7075 to develop the full properties of the alloy.

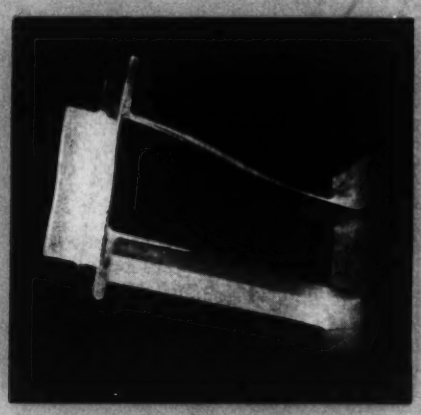
Alloys 4032, 2218 and 2018 retain their strength better at elevated temperatures than the other alloys. Parts that must undergo repeated loading at high temperatures, such as pistons and cylinder heads for aircraft engines and pistons for heavy-duty diesels, are typical applications.

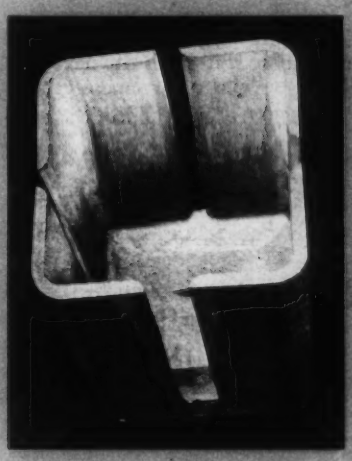
Maintaining dimensional stability at elevated temperatures requires maximum freedom from growth and from creep under sustained loading.

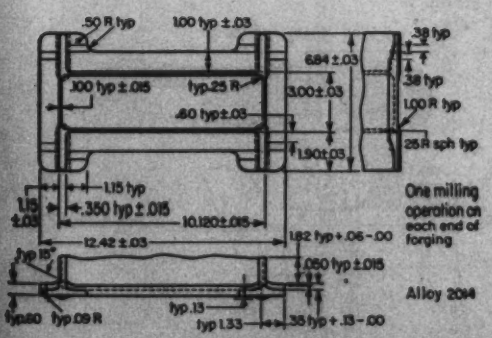


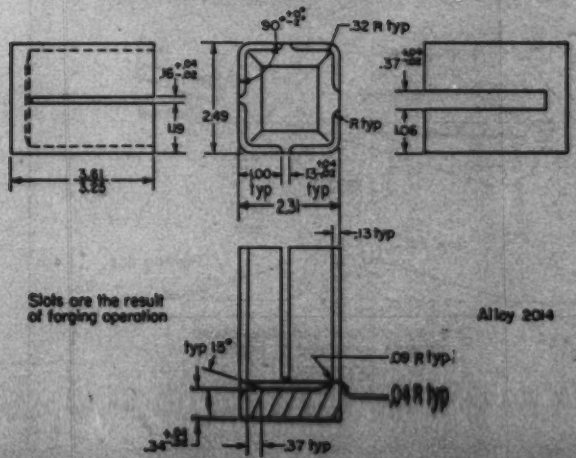
trolled die sinking and forging practices necessary to produce forgings of this type. The designer should realize that departures from "normal" design are reflected as an increase in cost. Economic studies should be made to determine the feasibility of using a precision rather than a conventional forging.











High thermal conductivity and a low coefficient of thermal expansion are also necessary qualities in these forgings. The choice among alloys 4032, 2218 and 2018 depends on the particular combination of thermal and mechanical properties desired.

Alloy 6061 is specified primarily for its superior welding and brazing qualities. It has excellent resistance to corrosion, and is suitable for forgings that are to be joined to other parts of the same composition. Alloy 6061 has mechanical property characteristics similar to those of alloy 6151 and is also suitable for many commercial forgings.

Alloy 2025 is a special-purpose material, employed primarily for aircraft propellers; its readily forgeable characteristics make it also desirable for superchargers for reciprocal and turbine engines and similar parts. Although substantial tonnages of alloy 2025 forgings are produced, the use of this alloy is generally confined to the applications listed above.

Forging Design: Perhaps the first problem to be considered in the design of a closed-die forging is parting line location. Ideally a parting line would be avoided by sinking the impression in the lower die half only, *Fig.* 2. Improper location

Fig. 2—Parting line location can affect both cost and quality of light-alloy closed die forgings. Placing the impression entirely in one die results in an *economical* forging, but forging sections are relatively heavy. Locating the parting line at an angle with the forging plane is *undesirable* because excessive side thrust forces would require expensive die counterlocks. Inclining the forging in the die is *good*. Square end surfaces with natural draft are thus possible. *Preferred*, primarily for economy reasons, is the double forging which is symmetrical about the center line

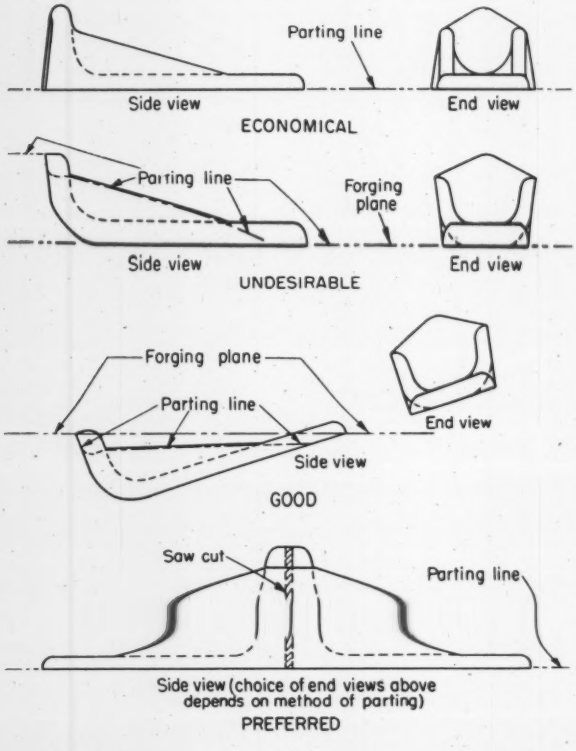
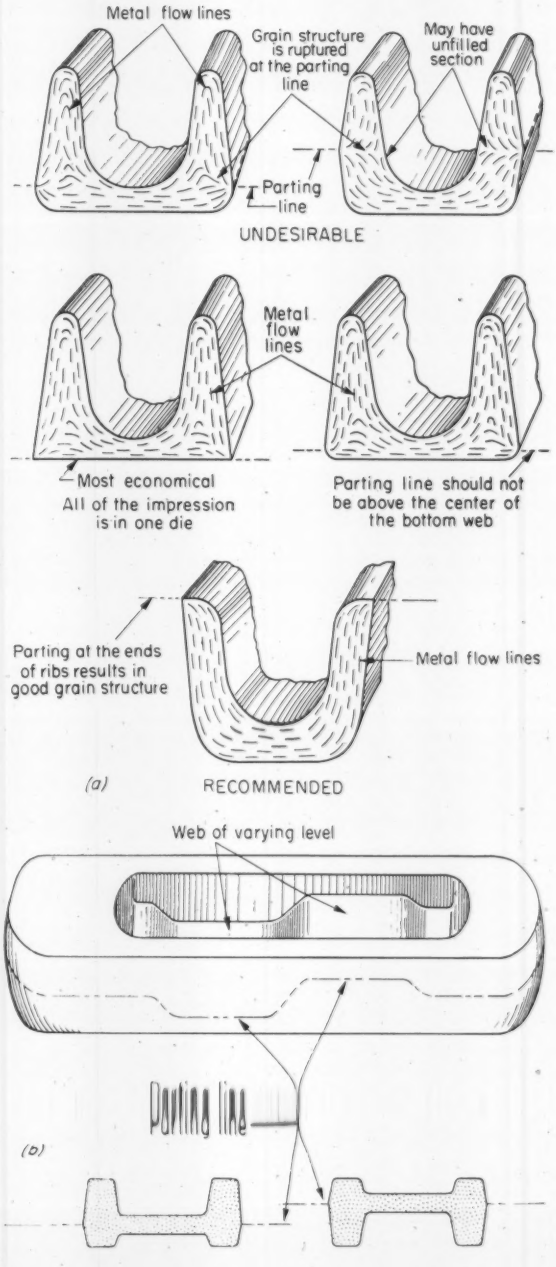


Fig. 3—Incorrect selection of the parting line can result in unsound forgings because of undesirable metal flow patterns, *a*. When the level of a web varies, the parting line should follow the web to produce a sound forging, *b*


Metal flow lines
Grain structure is ruptured at the parting line
May have unfilled section
Parting line
UNDESIRABLE
Metal flow lines
Most economical
All of the impression is in one die
Parting line should not be above the center of the bottom web
Parting at the ends of ribs results in good grain structure
Metal flow lines
(a)
RECOMMENDED
Web of varying level
Parting line
(b)

of a parting line can create an undesirable and unsound forging, *Fig.* 3.

Next step is the selection of the proper draft angles or taper to which the impression will be sunk in the die to allow easy removal of the forging from the die. Draft angles are greatly influenced by the type of equipment in which the piece is forged. When presses are used, for example, ejectors or knockout pins can be built into the dies to allow draft angles to be reduced as mentioned earlier to zero degrees in some cases. While larger draft is desirable, draft for standard press forgings may be from 1 to 3 degrees.

When a forging is produced by a hammer draft angles should ordinarily be specified at 5 to 7 degrees. However, draft angles as low as 3 degrees can be achieved. If there is a deep cavity in one half of the die and a shallow one in the other half, the draft angles in the latter must be substantially greater than the 5 to 7 degrees to avoid a step in the forging and the resulting appearance of mismatch. This practice involves what is generally called "matching draft," *Fig.* 4. However, where a step is not detrimental, the forging can be produced that way.

Another important factor in forging design is the radii on corners of the forging. A low-cost approach is to use a consistent corner radius so that the die sinker can use the same cutting tools throughout the die sinking operation. Since the shape of the cutting tool determines the corner radii, the cutting tools must be changed if different radii are used.

Care must be taken to avoid sharp corner radii, since they boost die and forging costs considerably. Sharp radii are difficult to fill, since gas pockets may form in the dies and hold the metal back. Where sharp corner radii are a must, vents are sometimes cut in the dies to allow gases to escape or an insert die is employed. This involves extra expense, however. In conventional forging dies where inserts are not employed, excessively small corner radii always increase the difficulty and cost of forging operations as well as decrease the die life.

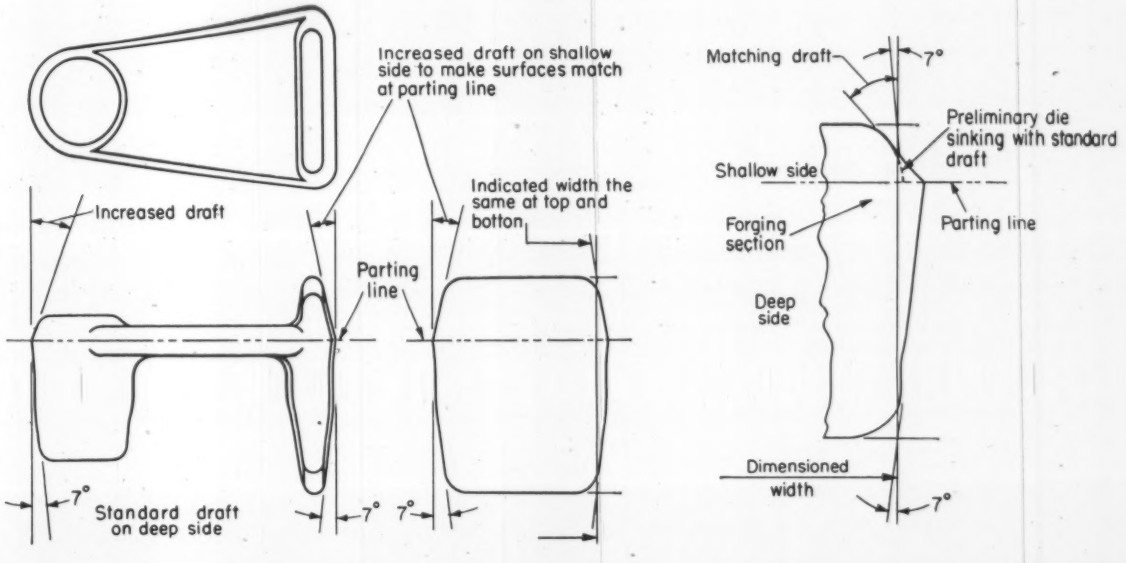
Another practice that will save a sizeable amount of die sinking time is the maintaining of ribs and similar sections of a forging with unequal heights to constant widths at the top rather than at the base. If the die sinker must continually be traversing the cutter laterally to maintain

Table 2—Standard Mismatch Tolerances*

Weight Range		
Aluminum Forgings (lb)	Magnesium Forgings (lb)	Tolerance (in.)
0-1	0-1	0.015
1-7	1-5	0.018
7-13	5-9	0.021
13-19	9-13	0.024
19-25	13-17	0.027
25-31	17-21	0.030
31-37	21-25	0.033
37-43	25-29	0.036
43-49	29-33	0.039
49-55†	33-37§	0.042

* Long, narrow forgings may require larger tolerances
† For forgings heavier than 55 lb, add 0.001 in. to tolerance for each additional 2 lb.
§ For forgings heavier than 37 lb, add 0.001 in. to tolerance for each additional 1 1/3 lb.

Fig. 4—If a forging is not symmetrical about the parting line, draft angles in the shallow portion must be much greater than those in the deep portion to avoid the appearance of mismatch. The matching draft surface should be tangent to the corner radius produced with a standard draft angle cutter



a constant width of cavity, he can spend an unbelieveable amount of time doing just that, and he must blend in all surfaces by hand. However, if he is permitted to let a cavity vary at the parting line with changing depths, a substantial amount of time and money can frequently be saved, *Fig.* 5.

Another important design consideration is involved in the fillet radii, which are the curvature at the base of a rib or web where one such element of the forging blends into another. If these are too small, they can easily result in a defect known as a cold shut, *Fig.* 6. Some recommended standards for fillet radii are given in *Figs.* 7 and 8.

It has been stated that no-draft, precision forgings can be designed with smaller than standard fillet radii with an increase in cost. It should be remembered at the same time that smaller than standard fillet radii tend to make it more difficult to forge small, thin web sections. Web sections in a forging have often been a point of controversy between designers and forging manufacturers. Aircraft designers like to save weight in webs because they usually represent metal near the neutral axis which has little value beyond holding the forging together. Forging producers, however, try to avoid thin web sections because they are hard to forge. They chill quickly and the metal becomes hard to move. As a result, it punishes the dies and the forging machinery itself. While thin webs can be produced, they usually mean extra operations, extra die equipment and extra costs. Punchouts are desirable, especially when the forging is blocked in with side flanges and are essential for developing thin webs in large forgings.

Tolerances: A number of basic tolerance considerations must be kept in mind when designing for aluminum forgings. These tolerances include:

Mismatch: This occurs when the top and bottom dies do not come together correctly. This difficulty is only completely absent in flat top dies where the entire forging impression is sunk in

Fig. 5 — Ribs and similar sections of a forging having unequal heights should be maintained at a constant width at the top rather than at the bottom. Die cost is kept to a minimum by this practice

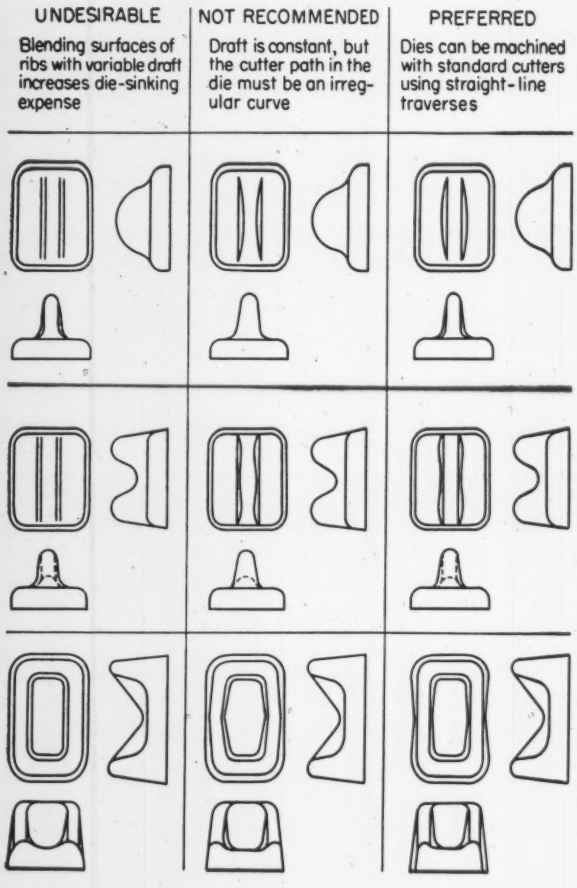

UNDESIRABLE
Blending surfaces of ribs with variable draft increases die-sinking expense
NOT RECOMMENDED
Draft is constant, but the cutter path in the die must be an irregular curve
PREFERRED
Dies can be machined with standard cutters using straight-line traverses

Fig. 6—Ample fillet radii result in smooth metal flow and sound forgings. Radii which are too small cause forging defects

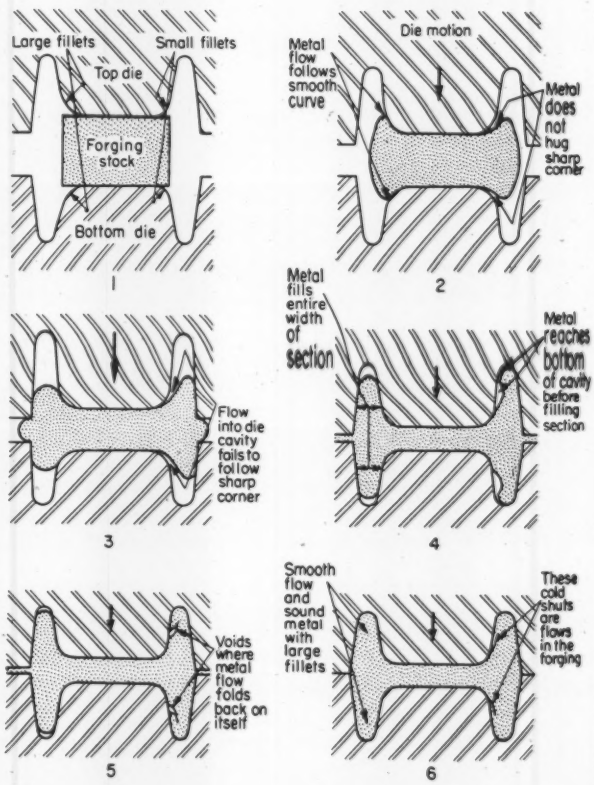


Table 3—Standard Die Closure Tolerances

Weight Range: Aluminum Forgings (lb)	Weight Range: Magnesium Forgings (lb)	Tolerance (in.)
0–¼	0–¼	+0.032, −0.010
¼–1	¼–1	+0.032, −0.015
1–4	1–3	+0.045, −0.032
4–17	3–11	+0.062, −0.032
17–24	11–16	+0.078, −0.032
24–50	16–33	+0.093, −0.032
50–100	33–67	+0.125, −0.045
100–250	67–170	+0.287, −0.062
250—	170—	+0.250, −0.062

Table 4—Standard Length or Width Tolerances

Length or Width (in.)	Exterior Tolerance (in.)	Interior Tolerance (in.)	Step and Center Tolerance (in.)
0-8	+0.032 −0.016	+0.032 −0.016	±0.016
Over 8*	+0.004 −0.002	+0.002 −0.004	±0.002

*Tolerances given should be added for each inch over 8 inches.

the bottom die-half. The causes are temperature differentials between the top and bottom dies. Many jobs are unbalanced and produce side thrust which throws the dies out of match. Die locks are used to combat this but are not always completely effective. Standard mismatch tolerances are given in *Table* 2.

Thickness Tolerance: This is generally referred to as die closure tolerance, since it results when the top and bottom dies do not fully meet when the part is finished. Standard die closure tolerances are shown in *Table* 3.

Length and Width Tolerances: This is the most difficult to hold to narrow limits and yet at the same time is frequently the most critical to customers. Maintaining length and width tolerances is extremely difficult, since the coefficient of thermal expansion of aluminum is twice that of the steel dies and the temperature change on cooling to room temperature is 500 to 800 F.

The difficulty increases, of course, with increase in the overall dimensions of the forging. A 10-ft part will contract almost an inch in cooling from forging temperature. In addition to this, the cavity in the die increases in size as a result of wear

Fig. 7—Recommended minimum radii for corners and edges

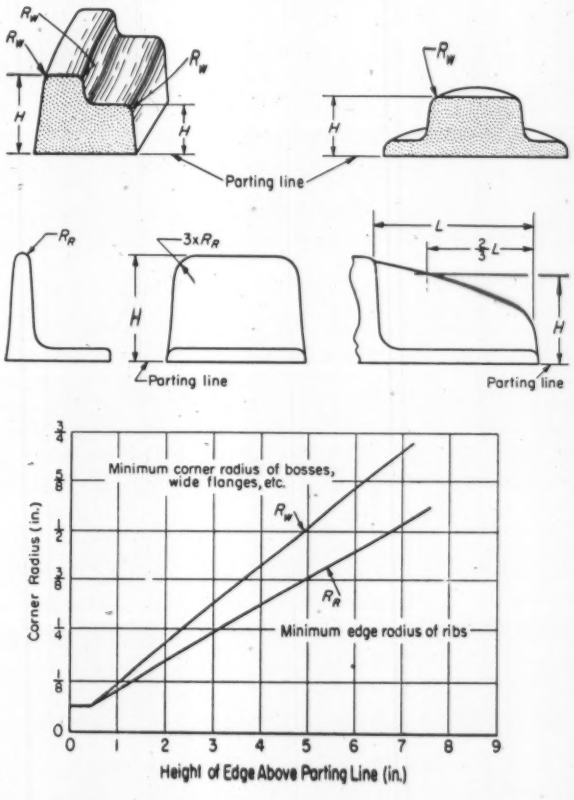
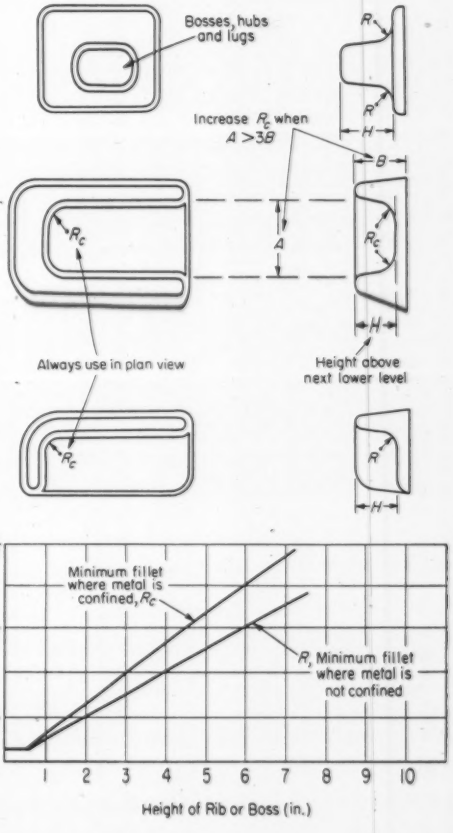


Fig. 8—Recommended minimum radii for ribs and bosses



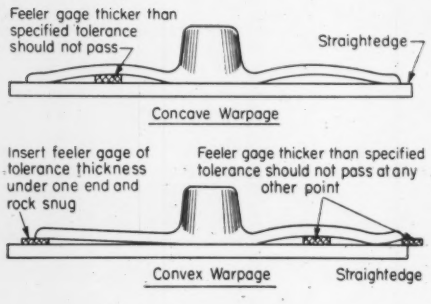

Feeler gage thicker than specified tolerance should not pass
Straightedge
Concave Warpage
Insert feeler gage of tolerance thickness under one end and rock snug
Feeler gage thicker than specified tolerance should not pass at any other point
Convex Warpage
Straightedge

Table 5—Standard Straightness Tolerances

Length Range (in.)	Tolerance (in.)
0-9	1/64
9-18	1/32
18-30	3/64
30-45	1/16
45-60	3/32
60-80	1/8

and die maintenance. As a result of these facts, it is evident that the closer the tolerance specified on length and width, the shorter the effective life of an expensive die. Length and width tolerances are given in *Table* 4.

Flash Extension or Trim Tolerance: This tolerance specifies the condition of the flash on a forging. On smaller forgings, an even trim is extremely difficult to achieve. The problem is not critical in large forgings, since most of these are hand trimmed.

Straightness: Straightness tolerances, *Table* 5, are applied to continuous surfaces formed by a single die. They are measured separately and independently of all other tolerances by using a straightedge or contour template.

Standard straightness tolerances depend on the length of the line on which the measurement is made. For curved surfaces, this dimension would be the length of the template contact edge as checked with a flexible tape.

In the case of the new precision forgings where minimum draft angle is involved, straightness must be carefully watched. Since the parts have little draft, if any, die straightening is usually impractical.

Probably the most important recent advance in aluminum forging is the improvement in tolerances. While these close-tolerance forgings have been limited in the past to relatively small parts, the principles involved are being projected to fit the giant presses of the heavy press program. With these larger forgings, however, the problems of precision forging become magnified considerably. Large aluminum forgings are made from preheated stock, then heat treated and aged. These operations tend to cause aluminum to shrink or expand, and this expansion and contraction varies with different aluminum alloys. In precision-forging production, these conditions must be controlled accurately so that a die can be sunk with the proper shrink allowance. Straightening the larger forgings also becomes extremely difficult.

Tips and Techniques

Ink-Stamping Part Numbers

ON PARTS such as castings, the usual methods of "casting-in," engraving or metal stamping the part number are relatively costly. Also, they may cause deformation or be a stress-concentration point to cause later failure.

Stamping with ink is a method that has proved to be successful. Regular stamp-pad inks cannot be used on castings, but a special ink,* available in several colors, has worked out well. Other information, such as labels or connection points, can also be ink-stamped.

Our system on castings is to use two drawings and two part numbers—one for the casting itself (pattern), and one for the finished part. The part number for the rough casting is stamped on a surface later to be machined. The final part number is stamped on the finished part. Thus, the same basic casting can be used for two different finished parts without upsetting the numbering system or imposing extra work in grinding off or changing the original casting number.

If ink-stamped numbers on the rough casting cannot be located so they will be machined off, a special remover† can be used.—KARL F. THEOBALD, *Link Aviation Inc., Binghamton, N. Y.*

*Alcosol ink, Jas. H. Matthews Co., 3942 Forbes St., Pittsburgh 13, Pa. †V37 paint remover, Moran Paint Co., Dayton, O.

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, *Machine Design*, Penton Bldg., Cleveland 13, O.

Correction

In the article entitled "Design and Applications of Powder-Metal Bearings," December, 1955, Page 162, the formula should read $W = 12\,KL/\pi N$ where W = bearing load, pounds; L = bearing length, inches; K = constant; and N = shaft speed, rpm.

By Ray C. Johnson
Senior Design Engineer
Eastman Kodak Co.
Rochester, N. Y.

How to design high-speed

CAM MECHANISMS

for optimum cam and follower proportions

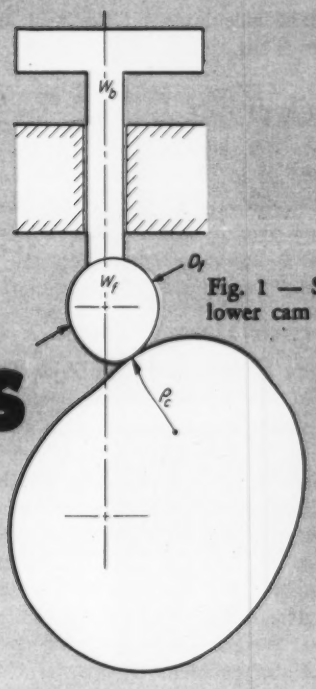


Fig. 1 — Sliding follower cam mechanism

IN HIGH-SPEED machinery, where inertia forces are important, cam mechanisms must be carefully designed to obtain long life. Improper design generally results in either (1) exorbitant wear of cam and follower contact surfaces due to high contact stresses, or (2) early failure of the cam follower itself.

For minimum surface wear, contact stresses between follower and cam surfaces must be alleviated. These contact stresses can be minimized by using correct design procedures in (1) development of the follower body motion and (2) design of the physical cam mechanism itself.

The importance of cam and follower motion from a dynamics standpoint has been accented by the attention this subject has received over the past few years. However, certain physical characteristics of the cam mechanism itself can be equally important in a completely satisfactory design. This article will develop a procedure for designing an optimum physical cam mechanism after the follower body motion has been developed to give desirable dynamic characteristics.

Throughout this analysis, frictional and gravitational forces are assumed to be small in comparison with the inertia and cam contact forces. This is a valid assumption for most high-speed machinery. The effect of the spring force in a spring-loaded cam is illustrated in a later example. Presence of such a spring does not affect the optimum design in any manner. Hence, spring forces will be omitted in the following derivations.

Sliding-Follower Systems

In any cam mechanism, the follower body consists essentially of two parts. They are the main body and the contacting follower. The main body is the part which must be moved by the cam to perform its desired function, and it should be designed as light as possible. The contacting follower merely serves as a tool for transmitting the desired motion to the main body from the cam with a minimum of contact stress. Generally, in high-speed machinery, a ball bearing is used for the contacting follower.

Assuming small pressure angles, since large diameter cams are desirable, the force exerted by the cam in accelerating the follower body in the upward direction in *Fig.* 1 is the summation of masses times their accelerations, or

$$P \approx \frac{W_b + W_f}{g} a$$

The contact stress between the follower and cam

can be calculated by the well known Hertz solution. Thus,

$$s = k_1 \sqrt{\left(\frac{W_b + W_f}{T}\right) a \left(\frac{D_f + 2\rho_c}{2\rho_c D_f}\right)} \quad \ldots\ldots (1)$$

where

$$k_1 = 0.798 \sqrt{\frac{1}{g\left(\frac{1-\nu_f^2}{E_f} + \frac{1-\nu_c^2}{E_c}\right)}} \quad \ldots\ldots (2)$$

Equation 1 shows that for a flat-face follower, where D_f is infinity, the total weight ($W_b + W_f$) should be as small as possible.

Incidentally, follower main body weight, W_b, includes the weight of the driven load. Also, to be precisely correct, the follower weight, W_f, should include any additional structure required for supporting a follower properly, such as a mounting yoke. Refinements of this nature, however, add complications and generally have little practical significance. A plot of contact stress versus follower weight would generally be very flat at the region of optimum design.

From now on, consider that the follower is a standard ball bearing selected from a family of ball bearings all having the same design proportions. The follower bearing weight can then be related to its physical dimensions by

$$W_f = k_2 T D_f^2 \quad \ldots\ldots (3)$$

Nomenclature

- a = Tangential acceleration of mass center of follower bearing, in. per sec^2
- c = Spring force factor
- D_c = Mean diameter of cam, in.
- D_f = Diameter of follower bearing, in.
- E_c = Modulus of elasticity of cam surface material, psi
- E_f = Modulus of elasticity of follower surface material, psi
- F_s = Force exerted by the return spring on the follower body, lb
- g = Gravitational acceleration, in. per sec^2
- I_h = Mass moment of inertia of follower main body and driven mass about axis of rotation, exclusive of follower, lb-sec^3-in.
- k_1, k_2 = Constants
- P = Contact force between the follower and cam surface, lb
- R = Center-to-center distance in *Fig.* 2
- s = Contact compressive stress between follower and cam surface, psi
- T = Width or thickness of follower bearing roller, in.
- W_h = Weight of follower main body and driven weight, exclusive of follower bearing, lb
- W_f = Weight of follower bearing, lb
- ν_c = Poisson's ratio for cam surface material
- ν_f = Poisson's ratio for follower surface material
- ρ_c = Radius of curvature of cam surface at point of contact, in.

where k_2 is merely a constant of proportionality. From Equations 1 and 3,

$$s = k_1 \sqrt{\left(\frac{W_b}{T D_f} + k_2 D_f\right) a \left(\frac{D_f}{2\rho_c} + 1\right)} \quad \ldots\ldots (4)$$

From Equation 4, it can be shown that an optimum size of follower bearing exists which minimizes the contact stress between cam surface and follower.

It is often theorized by designers that the roller follower used should be of the smallest available diameter, since then the minimum inertia will be driven by the cam. It is true that this assumption minimizes the contact *force*. However, the contact *stress* is *not* minimized in that manner.

If the follower diameter is too small, the contact stress becomes very high because the radius of curvature of the follower at the contact point is then too small. On the other hand, if the follower diameter is too large, the contact stress again becomes very high since then the inertia (large follower weight) driven by the cam is too large, resulting in very large contact force and stress.

Hence, an optimum size of roller follower exists with regard to the contact stress, s. This desired size can be found by taking the partial derivative of s with respect to D_f and equating it to zero. Performing these operations with Equation 4, and combining the results with Equation 3, show that the stress is minimized when

$$W_f = \frac{W_b}{1 + \frac{D_f}{\rho_c}} \quad \ldots\ldots (5)$$

It is difficult to use Equation 5 in original design, since exact values of both D_f and ρ_c are not initially known.

Equation 4 shows that the contact stress s is decreased by increasing the cam radius of curvature, ρ_c. For any point of operation, the cam radius of curvature is increased by using a larger size of cam. Hence, cams having a large mean diameter should be used, and it is generally found that $\rho_c \geqq D_f$ in the important region where the cam is driving the follower. Hence, the ratio D_f/ρ_c will generally lie somewhere between one and zero. Thus the initial choice of the follower bearing should be made according to

$$W_b \geqq W_f \geqq \frac{W_b}{2} \quad \ldots\ldots (6)$$

Equation 1 shows that for an optimum follower weight W_f, stress s is further decreased by having T and D_f as large as possible. Hence, in selection of a ball bearing having the approximate optimum weight from Equation 6, the one having the largest diameter D_f and largest thickness T should be chosen if such a choice exists.

As mentioned, contact stress s is decreased by increasing the mean diameter of the cam. However, too large a cam mean diameter results in

too great a speed of rotation for the follower bearing, thus decreasing its life. Therefore, although a cam mean diameter as large as possible should be selected, it should not be so large that the follower speed of rotation is exorbitant. It is also important to balance cams of large diameter.

As a final step in the design procedure, the cam should be laid out. Equation 5 can then be checked in the cam driving range to see whether or not the follower originally selected is near the optimum size, since then values of ρ_c and D_f will be known.

Pivoted-Follower Systems

A derivation similar to the foregoing one can be made for a pivoted-follower body type of cam mechanism, *Fig.* 2. For this type of problem, the follower bearing should be chosen according to

$$W_f = \frac{g}{1 + \frac{D_f}{\rho_c}} \left(\frac{I_b}{R^2} \right) \qquad (7)$$

Again assuming that $\rho_c \geqq D_f$ prevails in the cam driving region, the follower body weight should be selected according to

$$\frac{I_b}{R^2}\, g \geqq W_f \geqq \frac{I_b}{2R^2}\, g \qquad (8)$$

The equation for the contact stress, incidentally, is

$$s = k_1 \sqrt{\left(\frac{\frac{I_b}{R^2} g + W_f}{T} \right) a \left(\frac{D_f + 2\rho_c}{2\rho_c D_f} \right)} \qquad (9)$$

where k_1 is given by Equation 2.

Design Recommendations

After the follower body motion is developed according to the best possible provision for the dynamics of the system, the physical cam mechanism should be designed with the following points in mind:

1. Main follower body should be designed for minimum weight with acceptable rigidity.
2. Select the contacting follower bearing according to either Equation 6 for a sliding-follower cam mechanism, or Equation 8 for a pivoted-follower type. If a choice of several bearing designs of approximately the same weight exists, choose the one having the largest diameter D_f and thickness T.
3. Choose as large a cam mean diameter D_c as possible, remembering that the follower bearing load rating for its speed of rotation should not be exceeded.
4. After layout of the cam profile is complete, Equations 5 or 7 may be used in the cam drive region to see whether or not a cam follower near the optimum size is being used. Generally, a further refinement will be unnecessary.

Longer life and more satisfactory service can be expected from a cam mechanism if the preceding steps are observed in the original design. Optimum design of this nature is becoming more and more important in high-speed machinery. Not only are inertia forces and stresses much greater per cycle of operation, but many more cycles occur per unit of time and, hence, possibility of premature failure increases.

Examples

Suppose that it is desired to move a body with approximately simple harmonic motion using an eccentric, circular cam as shown in *Fig.* 3. Undoubtedly, a slider-crank mechanism would be more suited for this problem, but the eccentric circular cam used simplifies the illustration and yet shows the effect of optimum design. Suppose that the weight of the main follower body is 1 lb, that the cam is to rotate at 3200 rpm, and that the total throw is 1 inch.

From basic mechanics, and neglecting the relatively small frictional and gravitational forces

$$P = \frac{W_b + W_f}{g}\, a + F,$$

To assure contact between follower and cam, P should never become negative. Hence, the spring should be so designed that it always exerts a downward force on the follower body, as shown in *Fig.* 3. Also, so that the spring will be able to accelerate the follower body in the downward direction, the spring force at a given position of operation must be equal to some factor, c, times the inertia force. $(W_b + W_f)\ a/g$. The spring force factor, c, of

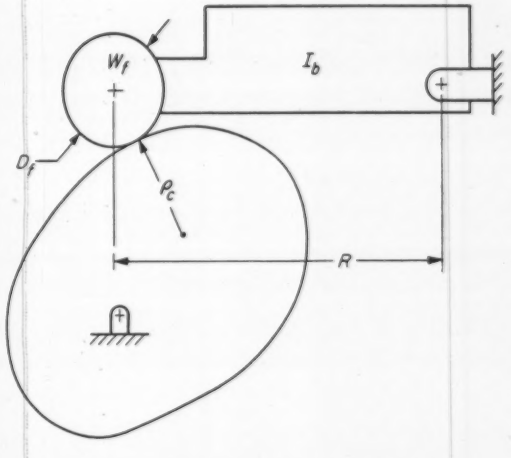


Fig. 2—Pivoted-follower cam mechanism

course is different for various positions of the follower body and its magnitude depends on the judgment of the designer. Hence, for any given position of the follower body,

$$P = \frac{W_b + W_f}{g} a + c \frac{W_b + W_f}{g} |a|$$

$$= \frac{W_b + W_f}{g} (a + c|a|)$$

The absolute notation for a denotes that although acceleration can either be plus or minus depending on the follower body position under consideration, the spring force remains in the downward direction at all times.

The value of P just derived can be substituted in the original Hertz stress equation. The only difference would be the term $(a + c|a|)$ which is a constant for any follower body position under consideration. Hence, the optimum design derivation is not affected in any manner by using a spring-loaded cam. However, stress Equations 1 and 9 should incorporate the spring force effect, as illustrated later in this example.

For the problem under consideration the inertia force varies sinusoidally as shown in the force plots in *Fig. 4*.

Suppose it is decided to use a compression spring so that it exerts a force of 1.2 $(W_b + W_f)\ a/g$ when the follower is in its uppermost position, and a force of 0.1 $(W_b + W_f)\ a/g$ when the follower is in its lowest position, thereby assuring continuous follower cam contact at all times. This is evident from *Fig. 4*, since the cam force P would then always be positive.

For this particular problem, the maximum contact stress is due to

$$P_{max} = 1.1 \frac{W_b + W_f}{g} a_{max}$$

Hence, the factor 1.1 will be incorporated in stress Equation 1 in the following calculations.

From basic mechanics, the maximum acceleration in simple harmonic motion is the amplitude of motion or, one half the total throw, times the square of frequency. Hence for this problem, the maximum acceleration is approximately

$$\frac{1}{2}\left[(3200)\left(\frac{2\pi}{60}\right)\right]^2 = 56{,}200 \text{ in. per sec}^2$$

A physical cam mechanism will now be designed by using three different methods and the maximum contact stresses for the three methods will be compared. The roller follower will be chosen from a commercial series of single-row radial type ball bearings.

Method 1—Optimum Design: From Equation 6, 1 lb $\geqq W_f \geqq$ ½ lb. Therefore, from catalog data on bearing weights, one weighing 0.65-lb appears to be a logical first choice. For this bearing, W_f = 0.65 lb, D_f = 2.8346 inches, and T = 0.6693-inch.

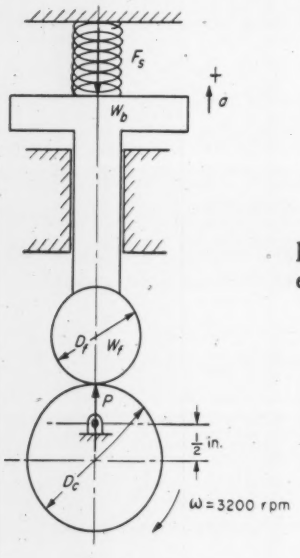


Fig. 3—Spring-loaded eccentric circular cam mechanism

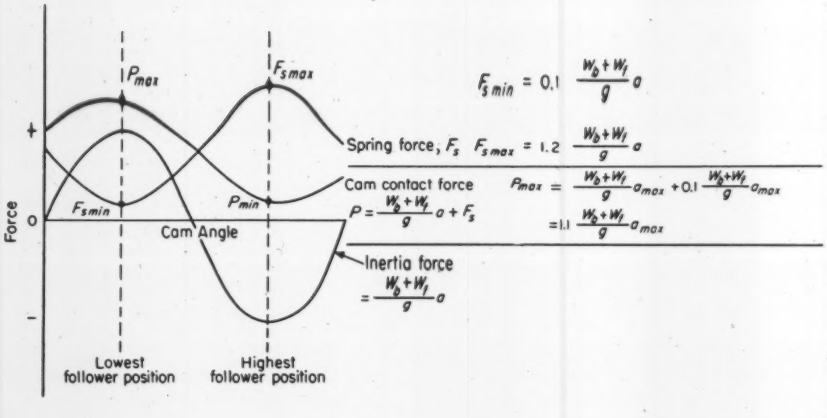


Fig. 4—Force analysis of example cam mechanism

Suppose space limitations only permit a mean cam diameter of $D_c = 6$ inches. This cam, of course, would have to be dynamically balanced.

The follower will then rotate with an average velocity of 7900 rpm. At this rate, the 3800-hour life rating of the bearing selected is 830 lb. Actually,

$$P_{max} = 1.1\left(\frac{1+0.65}{386}\right)56{,}200$$

$$= 264 \text{ lb}$$

To calculate the maximum contact stress, use Equation 1, modifying for the spring loading by the 1.1 factor. First, however, from Equation 2, with $E_1 = E_2 = 30{,}000{,}000$ psi and $\nu_1 = \nu_2 = 0.3$,

$$k_1 = 0.798\sqrt{\frac{30{,}000{,}000}{386(2)(0.91)}}$$

$$= 165$$

Thus, from Equation 1,

$$s_{max} = 165\sqrt{1.1\left[\frac{1+0.65}{0.6693}\right]56{,}200\left[\frac{2.8346+6}{2(3)(2.8346)}\right]}$$

$$= 46{,}500 \text{ psi}$$

Method 2—Follower and Cam Too Small: Suppose that the designer had decided to use as small a follower as possible and also a small cam, under the false assumption that it is always wise to use small parts in high-speed machinery.

Table 1—Summary of Example Designs

Design Method	Follower Dia. (in.) D_f	Bearing Weight (lb) W_f	Mean Cam Dia. (in.) D_c	Max. Sur. Comp. Stress (psi) s
1. Optimum	2.8346	0.65	6	46,500
2. System too small (Natural tendency is to design in this direction)	1.1811	0.07	2	82,900
3. Follower too large (Uneconomical and impractical)	4.9213	2.55	6	48,500

Thus, choice of a smaller bearing from the same series may lead to $D_f = 1.1811$ inches, $T = 0.3543$-inch, and $W_f = 0.07$-lb. Suppose the mean cam diameter is chosen to be 2 inches.

Hence, the same type of analysis as in *Method* 1 gives $s_{max} = 82{,}900$ psi.

Method 3—Follower Too Large: For high-speed machinery, the tendency is generally not to design in the direction of oversize followers. However, suppose for some unknown reason the designer chooses a bearing of too large a size for the follower.

Hence, using a larger bearing from the same series may lead to these proportions: $D_f = 4.9213$ inches, $T = 0.9449$-inch and $W_f = 2.55$ lb.

Suppose the mean cam diameter again is chosen as 6 inches, the largest permissible from space considerations.

Hence, the same type of analysis as in *Method* 1 gives $s_{max} = 48{,}500$ psi.

Although the stress value for this case is only slightly larger than that for *Method* 1, the follower size is unreasonably large and impractical, and certainly not economical.

Results obtained with the three methods are compared in *Table* 1.

Other Possible Effects

As stated earlier, frictional forces are considered to be negligible compared to the inertia and cam contact forces. It was also assumed that forces introduced by the load are negligible, except for the inertia load force which is included with the follower body inertia force. However, if the load introduces an appreciable noninertia force in the system, Equation 5 would take the form:

$$W_f = \frac{W_b + \dfrac{g\,F}{a + c|a|}}{1 + \dfrac{D_f}{c}}$$

where F is the introduced force.

Similarly, if the load introduces an appreciable noninertia moment in the system, Equation 7 would take the form:

$$W_f = \frac{g}{\left(1 + \dfrac{D_f}{c}\right)}\left[\frac{I_b}{R^2} + \frac{M_f}{(a + c|a|)R}\right]$$

where M_f is the introduced moment.

However, the effect of such frictional forces in high-speed machinery is generally negligible, and these refinements in calculation can usually be safely omitted.

Tips and Techniques

Graph Paper for Even Sectioning

SLIP regular-spaced graph paper under the view on the tracing to be sectioned and trace the graph lines. With different-space graph paper or by tracing only every other line, closer or wider spacing may be used.—JAMES V. WESTBERG, *Designers for Industry Inc., Cleveland.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, *Machine Design,* Penton Bldg., Cleveland 13, O.

A Short Guide to Simplified Report Writing

By Robert T. Marsh
Instructor of English
Tufts College
Medford, Mass.

REPORT CHECK LIST

Report No. 403 Title – Vibration Analyzer – Engineer – DJL – Date – March –

Stage of Development	Area of Responsibility	In Process	Completed
Rough draft	Project Engineer	✓	3/9
Editing and rewriting	Technical Writer	✓	3/12
Checking data and modifying	Staff Engineers	✓	3/15
Final draft	Project Engineer	✓	3/16
Typing	Typist	✓	3/17
Reproducing and mailing	Office Manager		3/20

Fig. 1—A suggested check list form for keeping tabs on the status of a monthly progress report

ALTHOUGH some of the routine of the engineering behind the report may be quite complicated, there is often no need for the time lag associated with the writing of the short periodic report. Those contributing to the group effort of modern project engineering should keep adequate records of work being done. The writing of the report on that work should be an easy task.

Reporting is a mechanical function of communication. Report writing is merely the reproducing of ideas on paper for the record. It may be the result of one man's efforts or the results of an organized effort on the part of many in a group.

Certainly many of the routine jobs of the business world are in the area of unimaginative, dull, and trite procedures. But the writing of engineering reports can be removed from that category. If the "mechanics" of report writing become second nature, the engineer can concentrate on essential features. And time spent can be reduced.

Plan: To whom is the report addressed? What are the facts wanted by the reader? What style would be best? Should the strictly impersonal style of the typical engineering report be adhered to? Should the passive voice be used throughout?

Check: Keep tabs on the progress of the report situation. Since the report-writing routine of the project engineer is a recurrent procedure, he should adopt a form check list for the stages of development of the report. This may be a rough chart or a formal graph, *Fig.* 1. It will give the administrator in the next echelon a quick view of the draft stage of all the reports being written for the same deadline. This system also gives the writers of each stage areas of responsibility.

Simplify: If the reader of a series of reports knows that the same type of information may be found in the same place, his reading of reports is considerably speeded. To have an efficient and adaptable format, tailor it to the needs of your company. Here is a suggested organization:

1. Cover page with necessary identifying information.
2. Table of contents giving page numbers and titles of main divisions as well as listing material in the appendix.
3. Introduction briefly indicating what is to follow.
4. Discussion giving a complete account of the accomplishments of the reporting period.
5. Projected program section including a general statement of what is expected to be accomplished during the next period.
6. Appendix containing graphs, diagrams, blueprints or photographs.
7. Abstract summarizing the entire report.

The writer of a progress report is a public relations man in a way. His report is a product of the teamwork of the entire staff of the project. Even though one person may sign the report, the accomplishment of every man on the staff is seen in each monthly progress report.

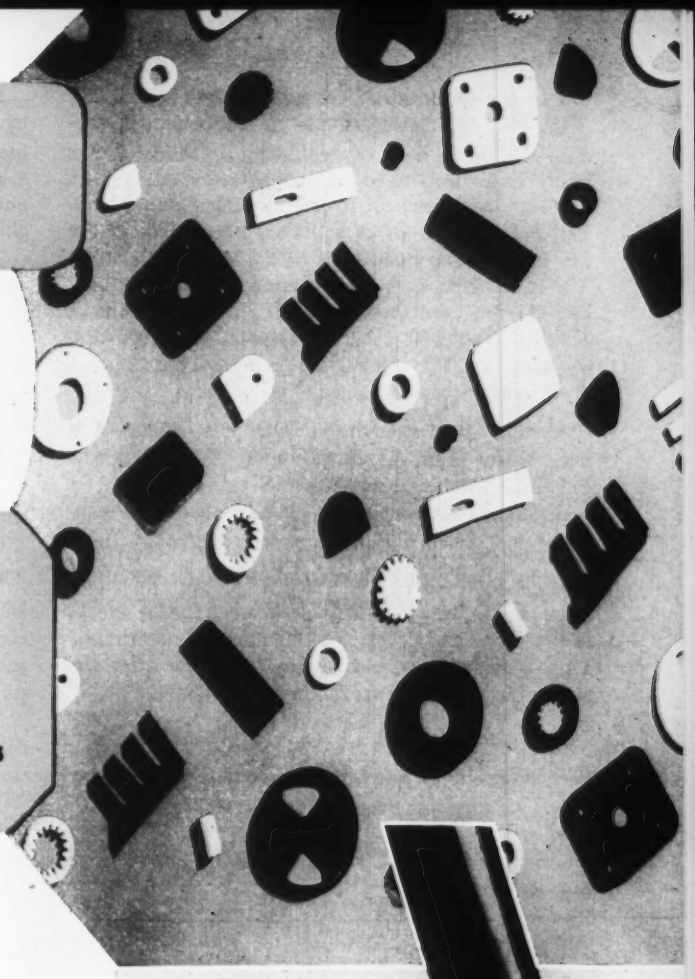
Do's and Don'ts of Simplified Report Writing

Do	Don't
Take a definite point of view and be consistent in it	Write long wordy paragraphs
Point up accomplishments	Expect the typist to correct your errors
Put important items in strategic positions	Be ashamed to receive criticism
Subordinate the obvious	Use slang words or poor grammar
Weed out irrelevant material	Present mere ideas as finished thought
Maintain continuity between reports	Strive for literary effect in engineering reports
Account for work that was projected in plans last month	
Clarify objectives for all experimentation and research	
Have conferences with staff members as the report is being written	
Consult a dictionary frequently	

Selecting and Specifying

FELT

- **Design properties**
- **Production characteristics**
- **Felt specifications**
- **Special treatments and laminates**



By William C. King
Executive Vice President
The Felters Co.
Boston, Mass.

FELT today is a carefully processed material, fully capable of handling many stringent design requirements.

It is a highly resilient material, with a predictable permanent set. It is not harmed by age, water, oil, gasoline or acid in normal concentrations. It is a successful sound deadening medium and an efficient filtering medium for air and liquids as well. It does not deteriorate under continuous operation, nor will it crumble under pressure. It forms an efficient barrier against grease, and prevents the flow of liquids and oils through bearings. It can be used to control both thrust and pressure vibrations, and it is also successfully used as a wick for feeding lubricants to bearings.

What is Felt?: Technically, felt is defined as "a fabric built up by the interlocking of fibers by a suitable combination of mechanical work, chemical action, moisture and heat, without spinning, weaving or knitting. It may consist of one or more classes of fibers: wool, reprocessed wool, and/or reused wool, with or without admixture with animal, vegetable and synthetic fibers."

Although felt is commonly thought of as a springy, spongy substance, it can be processed to almost any consistency from the softness of cot-

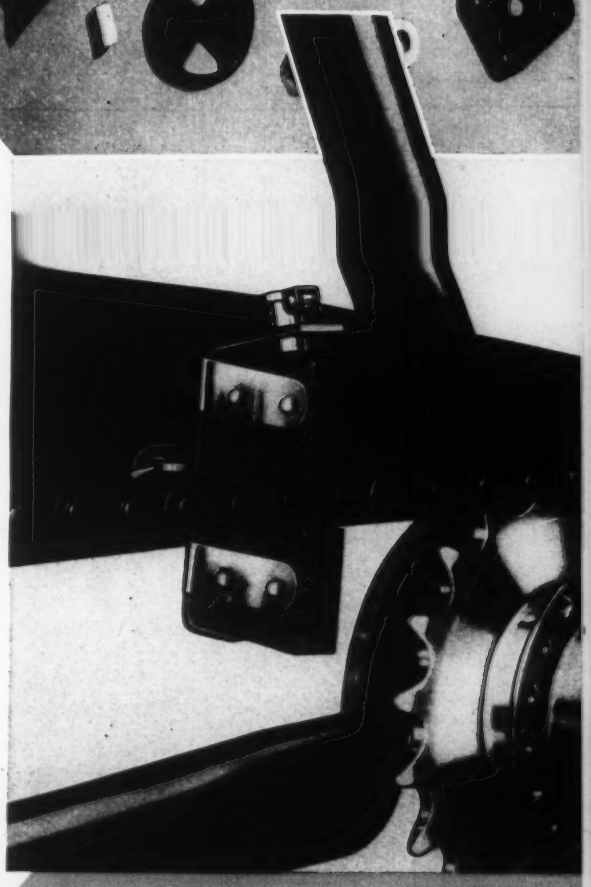


Fig. 1—Chain oiler and cleaner on this Columbia bicycle is made of felt, with a snap-cover oil fitting to supply the lubricant

ton to the hardness of seasoned wood.

Because felt can be made to conform to a specific thickness, density, resiliency or shade, it has many uses. Felt hard enough to be whittled by a knife is employed in polishing glass and metal. Felt soft enough to be squeezed into a ball in the fist is used for padding.

Felt cuts with a clean, nonfray edge. It can be die-cut, punched, skived, chiseled, turned, scarfed, ground or otherwise processed by common methods.

Mechanical Properties: Felts for engineering uses have been standardized by SAE and the Felt Assn., *Tables* 1 and 2.

Resiliency and strength of felt of several consistencies, ½-inch thick, corresponding to these Society of Automotive Engineers felt specifications, have been loaded to 1000 psi (far in excess of recommended practice). Thicknesses determined after 1 minute under load, and recovery after the load was removed, are shown in *Table* 3.

Environmental Conditions: Felt is not affected by normal atmospheric conditions, moisture, sun, heat or cold. Felts of several consistencies are designed into piano actions where replacement is not contemplated, and experience shows that felt's characteristics do not change over the years.

There is no change in felt at temperatures up to 212 F (100 C), at which point the wool loses its hygroscopic moisture and becomes harsh to the touch. When recooled, felt resumes its natural feel. Felt has withstood more than 30 days of 250 F dry heat without materially weakening its structure. Felt is the same at −60 F (−50 C) as at normal 74, and at −80 F (−62.22 C) its properties become only slightly different.

Noise and Vibration Absorption: To test the noise-deadening qualities of felt, pieces of 8 by 36 inch felt have been glued to ⅜-inch sheetrock, simulating conditions under which sound corrective material would normally be attached to the ceiling of a room. Absorption coefficients were

Table 1—Felt Classification and Requirements

Specification Number (SAE)	Specification Number (Felt Assn.)	Trade Designation	Color	Standard Width (inches)	Tensile Strength (psi, min)	Splitting Resistance (lb per 2 in. width, min)
F-1	16R1	Back check	White	60	500	33
F-2	16R2	Back check	Any color†	60	500	28
F-3	16R3	Back check	Grey	60	400	22
F-5	12R1	Extra firm pad	White	60	400	18
F-6	12R2	Extra firm pad	Grey	72	275	16
F-7	12R3	Extra firm pad	Grey	72	250	12
F-10	9R1	Firm pad	White	72	225	8
F-11	9R2	Firm pad	Grey	72	200	6
F-12	9R3	Firm pad	Grey	72	100	3
F-13	9R4	Firm pad	Grey	72	75	2
F-15	9R5	Firm pad	Grey	72	75	2
F-26	8R5	Soft pad	Grey	72	—	—
F-50	16R1X	Ball bearing felt	White	60	500	*
F-51	16R3X	Ball bearing felt	Grey	60	300	*
F-55	12R3X	Lining	Grey or black	60 or 72	200	*

*Not applicable to felts under $\frac{1}{16}$-inch thick; tensile strength only is recommended as indicative test.
†Except black or grey.

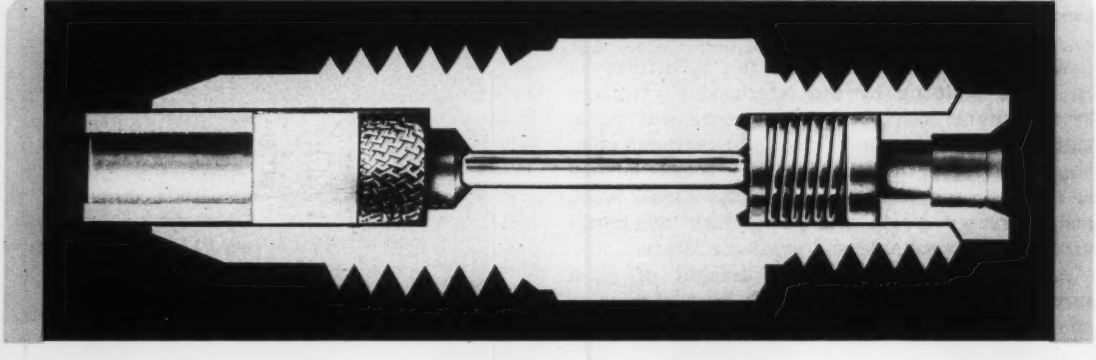


Fig. 2 — Filter in this metering unit, used on Willcox Gibbs sewing machines, is of porous felt

measured at the frequency of 512 cycles per second (standard for specifying absorption coefficients, calculating the reverberation time in a room, and the necessary amount of sound corrective material to be used), with the results shown in *Table* 4.

Advantages of mounting heavy machinery on felt pads have been indicated in many tests. For example, readings of vibration transmitted to the cement floor at locations adjacent to each corner of an Automatic Cotton King Dobby loom operating at a speed of 176 rpm, made both with and without felt under the legs of the loom, showed an average reduction in transmitted vibration of 70 per cent when the felt was used.

Other Design Properties: Felt has a low coefficient of sliding friction, as shown in *Table* 5.

Two other noteworthy properties of felt are: (1) felt is a wicking and filtering material, *Figs.* 1 and 2, because its fibrous construction gives it high capillary value which is varied by controlling the density of felt and the grade of fiber used, and (2) felt can be cemented to other surfaces. Adhesives are available which give bonds stronger than the felt itself.

Treatments and Special Felts: When some special property is required of felt, suitable treatments are applied to the felt during manufacture. Typical special treatments are described in *Table* 6.

Additionally, special types of felt in combination with other materials perform numerous services in engineering design, *Fig.* 3. For instance, a laminated combination of synthetic rubber and

Table 3—Deformation Characteristics

Grade (SAE)	Deformation Under Load (per cent)	Recovery (per cent of orig. thickness)
F-3	42.2	81.0
F-10	46.2	69.0
F-15	48.6	64.6

Table 2—Recommended Uses for SAE Felts

F-1: For oil retention in installations where felt is not compressed, for feeding low viscosity or light oil, and where unusual strength and hardness are required. Washers, bushings, wicks, door bumpers, polishing blocks and parts where wear and resistance to abrasion are required are typical uses.

F-2 and F-3: For the same general purposes as SAE F-1, and where a felt of slightly lower quality is satisfactory.

F-5, F-6 and F-7: For dust shields, wipers, grease retainer washers, wicks and in uses where a resilient felt is required.

F-10, F-11 and F-12: For grease and oil retention where the felt is confined and compressed in assembly. These grades are also recommended for dust shields under less severe operating conditions where F-5, F-6 and F-7 are not required.

F-13 and F-15: For sound deadening, chassis strips, spacers, dust shields, pedal pads, dash liners, and for mechanical purposes where abrasion and wear are not important factors.

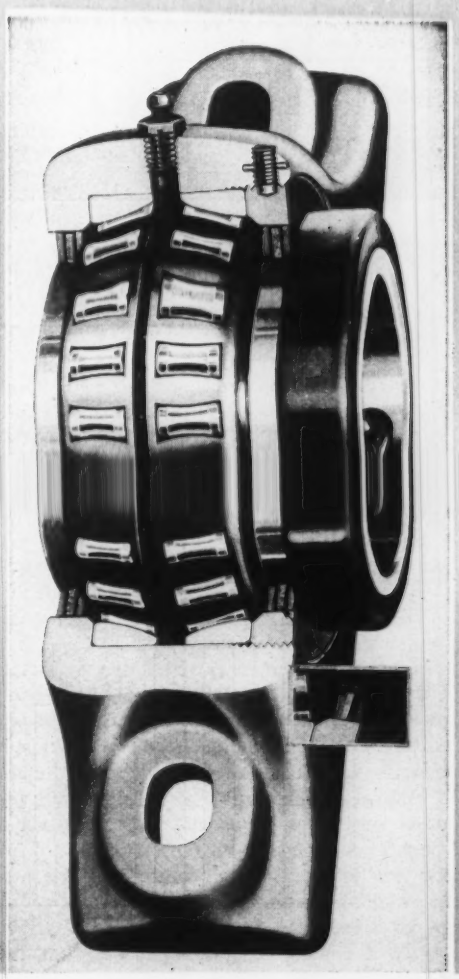
F-26: For packing or padding when held in place between other materials. This grade should not be used for mechanical purposes.

F-50: For ball and roller bearing oil-retainer washers and small dust-excluding washers. Also for mechanical purposes where an accurate, thin, smooth, high-grade felt is required.

F-51: For the same general uses as F-50 but in installations where tolerances and length of life are not as important. Also recommended for thin cut parts, gaskets and liners.

F-55: For anti-squeak strips and for lining when cemented to fiber or metal panels.

Fig. 3 — Contact type seals of felt laminated with synthetic rubber (inset) replace the usual labyrinth seal on Link-Belt pillow blocks when extremely dirty conditions are encountered



felt (Dufelt) is recommended for sealing of lighter oils when no head of oil exists.

Other laminations with felt are of rubber, Hycar, and Buna-S sheeting, used for oil or water seals and washers, and aluminum or lead foil on pad felts, for reflectant, acoustical and thermal-insulating applications.

Special coatings of latex on one or both sides of felt pads are used for nonskid typewriter pads, and coatings of rubber and starch sizing produce a stiff reinforcement for window channels.

For other uses, felt is incorporated with plastic to produce a water-repellent material suitable for rainwear (Mylar); with nylon webbing (heartfelt); with metallic thread (filon d'or) to yield a decorative material used for skirts and draperies; and with polyresins (All-Fab) for a wide range of industrial uses, such as underlining for vinyl.

Production Characteristics: Because felt does not ravel or fray when cut, it may be shaped by dies in an endless variety of forms, such as washers and gaskets of limitless sizes and shapes. Very hard grades of felt may be turned on a lathe like wood, as in the production of polishing wheels; or they may be cut by hollow spinning dies into round wicks which are used for railroad signal lamps and also to lubricate machinery—especially small machines such as electric razors.

Formed parts having undercut contours are shaped in some instances by carving very dense grades of felt, and sometimes by laminating several flat shapes by means of stitching or adhesives. Besides being turned and drilled mechanically, felt parts made of the very hard sheet felts may also be sculptured.

Still other felt parts are treated with sizing or plastic, then pressed or stretched over molds and either baked or allowed to harden in air. This method produces deep contours in thin sections.

Because felt is made in sheet or piece form, it is most economically punched or stripped. Regular shapes such as washers, disks, square or oblong pads, strips, and round or square wicks can

Table 4—Sound Absorption Characteristics

Grade (SAE)	Thickness* (inches)	Absorption Coefficient†
F-10	¼	0.50
F-15	¼	0.41
F-26	¼	0.42
F-26	½	0.61

*Glued to ⅝-inch sheetrock backing.
†At 512 cycles per second.

Table 5—Coefficients of Sliding Friction

Felt against smooth wood	0.32–0.42
Felt against glass	0.22–0.29
Felt against smooth metal	0.20–0.24
Felt against oiled* metal	0.18

*SAE 80 oil.

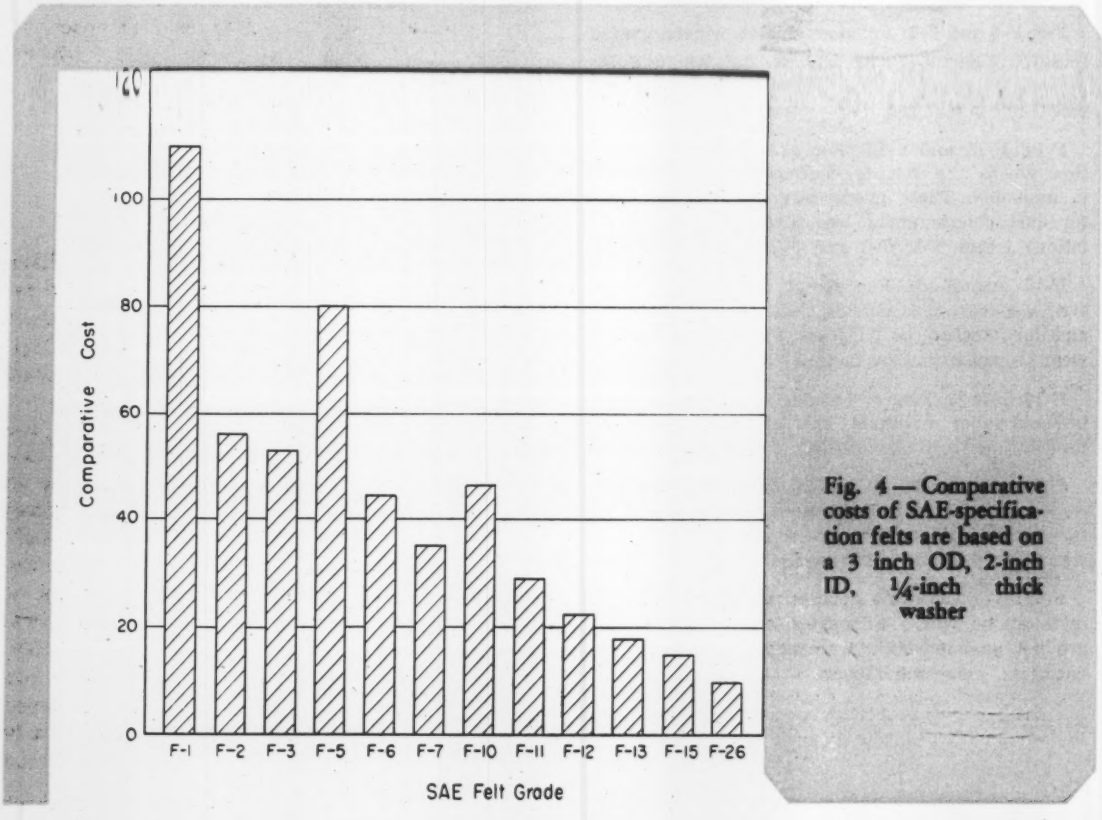


Fig. 4—Comparative costs of SAE-specification felts are based on a 3 inch OD, 2-inch ID, ¼-inch thick washer

be standardized, and a number of these actually are produced as "standard parts" by felt manufacturers. Many felt parts are required to fit a recess which can be accurately measured by usual machine shop methods. Comparison to a measured recess is often a practical method of checking felt parts, and simple recessed gages are often made for this purpose.

Cementing: In cementing felt to other surfaces, extreme absorptive properties of felt cause rapid absorption of solvents and liquids from cements.

Table 6—Special Treatments for Felt

Absorptive: Used in felts for stamp pads, ink rollers, tape moisteners, and the like. The compound applied to the felt causes a reduction of the surface tension of liquids, but does not affect the felt otherwise. It will not retain its full wetting out qualities indefinitely.

Sizing or Stiffening: Used when stiffness is required for better handling of cut parts in assembly, for support of a cut part with a thin wall, for clean cutting without fuzzy edges, and for preventing distortion of parts before installation. Chiefly used on felts which are not firmly felted.

Water Repellent: The felt is impregnated with a water-resistant, flexible, noncorrosive, nonleeching material, which sheds but does not render the felt impervious to water. Treated felt is used for weatherstripping, cowl stripping and as gasketing for box closures. It is not affected by sunlight and will not oxidize or become brittle. Best results are obtained when the firmer felts are treated in this manner.

Mothproofing: A fluorine compound, odorless and nontoxic in character, is applied to the felt. This is used principally on wool felts requiring long life in dark, dry, poorly ventilated places. The treatment does not impair texture, tensile strength or thermal transmission of the felt. For temporary storage, mothproofing can be effected by ordinary naphthalene flakes and paper wrapping.

Flameproof: Prevents felt from supporting combustion. Usually used on cotton, rayon and kapok felts, especially those used in aviation. Wool fiber is relatively slow-burning inherently, and rarely needs flameproofing treatment. The flameproof treatment does not increase resistance to deterioration by dry heat.

Mildewproof: This is an impregnation which adequately protects felt against mildew in moist, warm or wet places. It is sometimes recommended for felts specified to contain sizing, or which are exposed to bacteria or fungus growth. Main uses are in air-conditioning felts, silk-conditioning pads and similar articles, and the treatment is quite permanent. It is not required except in cases where peculiar conditions tend to promote growth of microorganisms.

glues and adhesives. To offset this quality, the usual method is to precoat the felt with a light application of the selected adhesive, which when dried forms a seal. Next, the usual coating of both the felt and the surface to which it is to adhere takes place. In many cases a latex spray or other inexpensive filler may be used for the sealing coat.

Specifying Felt: SAE specifications define the relation of weight to thickness, which in turn controls consistency of a felt. Established split and break tests control the strength of the finished felt; specified chemical content controls the fiber use, the permissible amount of sizing, amount of oil or other impurities. Thus, it is always preferable to use an SAE or Felt Association specification number in ordering felt for designing.

Factors usually defined are the SAE designation and the thickness desired, plus the part dimensions. It is preferred practice to cover felt parts by assigned part numbers and by scale prints.

Relative costs of SAE felts are approximated in *Fig.* 4. Specify quantities wanted, since prices per unit vary according to quantity. Because every order involves a setup charge and because automatic precutting is advantageous when volume runs high, it is best to inquire about prices on the largest reasonable amount of felt which might be needed, as well as the amount immediately required for a specific purpose. Disks, washers, rectangles, squares and wicks cut to length are generally priced per thousand units. Continuous wicking and strips are priced per thousand running feet.

It is virtually impossible—except at an increase in cost—to manufacture the average felt part so that an exact number of finished parts can be predicted. and a tolerance allowance of 5 per cent under-run or over-run is considered normal in the felt industry.

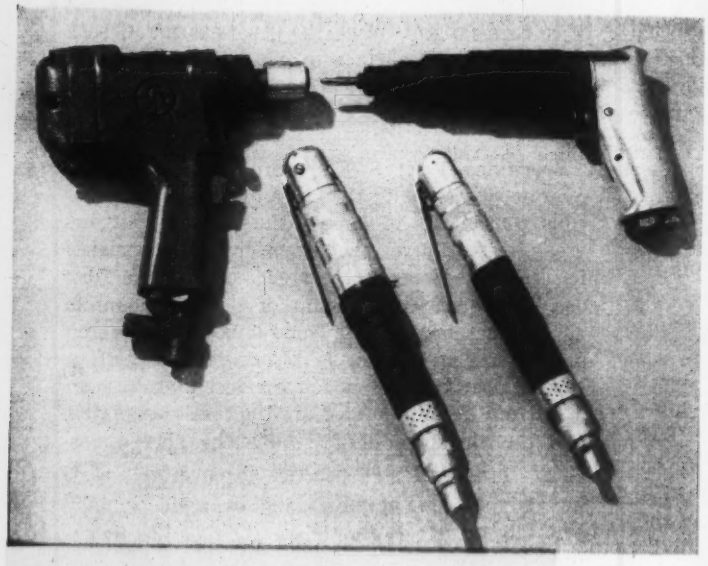
Vibrating Centrifuge

TEST specifications for certain guided missile assemblies require both linear and centrifugal acceleration tests. A two-directional centrifuge tester designed by Hugh Cox of Raymond Engineering Laboratory Inc. generates both motions simultaneously.

According to a report by the MB Mfg. Co., the tester consists of a variable-speed centrifuge constructed so the rotating arm can be vibrated in a horizontal plane. Flat-leaf supporting flexures connect the support bar and rotating arm assembly to the frame. These supporting flexures allow the supporting bar to move only in the direction of linear vibration. Fused links couple an MB Vibration Exciter to the suspended centrifuge assembly.

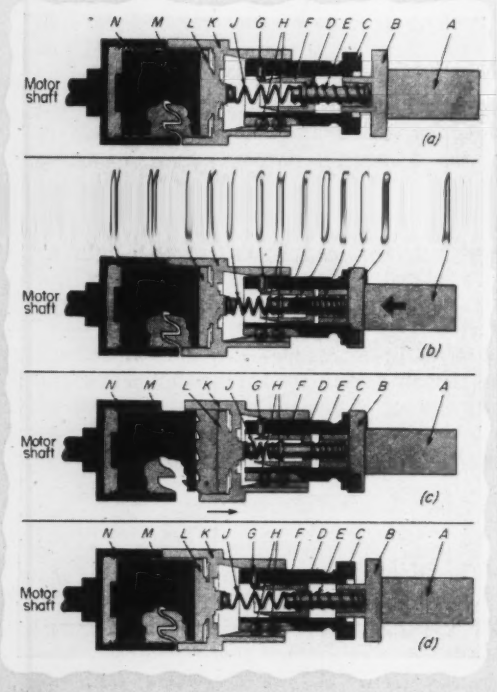
With the centrifuge, only one set of test data is necessary. More valid test results are believed possible because the tester is said to more nearly simulate actual operational conditions of missile flight.

Magnetic Clutch Controls Screwdriver Torque



A SERIES of new portable power screwdrivers and nutrunners features a magnetic controlled-torque clutch to give precise control of fastener tightness. Thirteen models, including both reversible and nonreversible types, handle screw sizes from No. 4 to 3/8-in. Products of the Chicago Pneumatic Tool Co., the pneumatically powered tools also incorporate a new type of acoustic baffle which lowers operating noise.

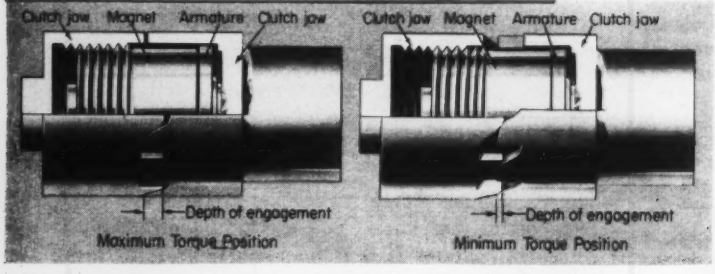
Positive disengagement with no continued impacting or ratcheting after the proper torque is reached is inherent in the design of the magnetic clutch. At *a*, with no axial pressure on the hexagonal spindle *A*, spring *J* holds latch pin *D* forward. Pin *D* holds clutch pin *B* forward and disengaged from the positive clutch jaw *C*. Magnet *M* holds armature plate *L* keeping torque clutch jaw *K* engaged with torque clutch jaw *N*. With the motor running all parts rotate except the hex drive spindle *A* and pin *B*.



When the tool is applied to the work, *b*, the spindle is forced in the direction indicated to engage pin *B* with jaw *C*. The drive spindle then rotates to drive the screw or nut. Motion of the spindle has also caused clutch pin *B* to move latch pin *D* and compress spring *J*. Lock pin *G* prevents motion of latch sleeve *F* and spring *E* is also compressed.

When the desired torque is reached, *c*, jaw *K* cams out of jaw *N* against the pull of magnet *M*. When the distance between magnet and armature plate *L* is about 0.015-in. magnetic pull is virtually zero. As jaw *K* moves in the direction indicated, its inner taper allows pressure of spring *E* to move sleeve *F* and pin *G*. The clutch is thus positively disengaged and locked by pin *G*. It will not re-engage as long as it is held on the work.

Removal of the tool from the work, *d*, allows spring *J* to push pin *D* forward disengaging pin *B* from jaw *C*. Latch sleeve *F* also moves forward allowing lock pin *G* to be pushed in by taper on jaw *K*. Jaw *K* then moves until armature plate *L* contacts the magnet *M*. The clutch is then re-engaged and ready for the next operation.



Torque setting of the clutch is adjusted by screwing the magnet in or out of the clutch jaw into which it is threaded. Both depth of engagement and angle of contact of the jaw teeth change.

Contemporary Design

Nomographs speed design of

Cantilever Beams

subjected to concentrated loads

MACHINE DESIGN Data Sheet

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MANY machine members are so loaded that they in effect are cantilever beams subjected to concentrated loading at one or more points. Calculations of stress and deflection often must be repeated several times before the best proportions are established. Purpose of the charts and data presented in this article is to facilitate such calculations.

The equation for maximum stress in a cantilever beam is

$$s = \frac{Mc}{I} = \frac{Plc}{I} = \frac{Pl}{(I/c)} \quad \ldots\ldots (1)$$

Terms are defined in the accompanying *Nomenclature*.

The equation for deflection at the load point is

$$\delta_l = \frac{Pl^3}{3EI} \quad \ldots\ldots (2)$$

When the load point is short of the end of the cantilever, the maximum deflection, at the end of the beam, can be determined from

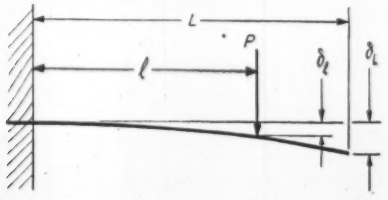
$$\delta_L = \delta_l \frac{3}{2}\left(\frac{L}{l} - \frac{1}{3}\right) \quad \ldots\ldots (3)$$

These equations are derived from the conventional beam flexure theories. They do not account for shear deflection, which is negligible in most cases. Neither are they applicable to extremely thin beams subjected to large deflections. This latter case has been discussed by Baltrukonis.*

Graphical solutions of Equations 1 and 2 are presented in *Figs.* 1 and 2, respectively. Characteristics of beam sections of different shapes are listed in *Table* 1.

Nomenclature

- c = Distance between neutral axis and extreme fiber, inches
- E = Modulus of elasticity, psi
- I = Moment of inertia, inches^4
- L = Length of beam, inches
- l = Distance to point of load application, inches
- M = Bending moment, lb-in.
- P = Load, lb
- s = Maximum stress, psi
- δ_L = Deflection of end of beam, inches
- δ_l = Deflection at load point, inches



Example 1: Assume the following problem conditions: Beam is 1.42-inch diameter brass; beam length L = 12.3 inches; load P = 84 lb; and load is applied at tip of beam ($l = L$). Find maximum stress and tip deflection. In this case δ_L will be equal to δl.

From *Table* 1,

$$I = 0.049\ (1.42)^4 = 0.199\ \text{in.}^4$$

$$\frac{I}{c} = 0.098\ (1.42)^3 = 0.280\ \text{in.}^3$$

Use *Fig.* 1 to find maximum stress s. Align P = 84 with l = 12.3, and read M = 1030 lb-in. Align M = 1030 with I/c = 0.280 and read s = 3700 psi.

Use *Fig.* 2 to find deflection at end of beam. Align P = 84 with l = 12.3 and spot Reference 1. Align E = 14,000,000 with I = 0.199, and spot Reference 2. Align References 1 and 2, and read δ_l = 0.019-inch.

Example 2: Assume a cantilever beam with two concentrated loads. Let the material be steel and the cross section of the beam a 1½-inch square. Also, P_1 = 870 lb at l_1 = 8 inches; P_2 = 550 lb at $l_2 = L$ = 14 inches, and the loads are applied on a corner of the square cross section. Again, find the maximum stress and the tip deflection.

Use *Fig.* 1 to find the maximum stress resulting

*J. H. Baltrukonis—"Design of Thin Cantilever Beams," MACHINE DESIGN, July, 1953, Pages 173-176.

from each of the loads independently, and add them. That is,

$$S = S_{-1} + S_{-2}$$

$$= 12{,}000 + 14{,}000 = 26{,}000 \text{ psi}$$

Use *Fig.* 2 to find the deflection resulting at each load point, and apply Equation 3 to the deflection at P_1 to find the resulting deflection component at the end of the beam. That is,

$$\delta_L = \delta_{l1} \frac{3}{2} \left(\frac{L}{l} - \frac{1}{3} \right) + \delta_{l2}$$

Using values from *Fig.* 2 gives

$$\delta_L = 0.012 \frac{3}{2} \left(\frac{14}{8} - \frac{1}{3} \right) + 0.040$$

$$= 0.025 + 0.040 = 0.065\text{-inch}$$

This same method can be applied to additional concentrated loads, whether or not one is located at the tip of the beam.

Table 1—Characteristics of Beam Cross Sections

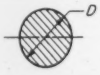
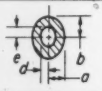
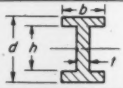
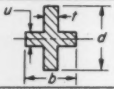
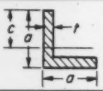
Section	Moment of Inertia I (inches^4)	Section Modulus I/c (inches^3)	Section Area (sq in.)
	$0.049\,D^4$	$0.098\,D^3$	$\pi\left(\frac{D}{2}\right)^2$
	$0.049\,(D^4 - d^4)$	$0.098\,\frac{(D^4 - d^4)}{D}$	$\pi\left(\frac{D^2 - d^2}{4}\right)$
	$\frac{bd^3}{12}$	$\frac{bd^2}{6}$	bd
	$\frac{b^4}{12}$	$0.118\,b^3$	b^2
	$\frac{bd^3}{36}$	$\frac{bd^2}{24}$	$\frac{bd}{2}$
	$0.7854\,b^3a$	$0.7854\,b^2a$	πab
	$0.7854\,(b^3a - e^3d)$	$0.7854\,\left(\frac{b^3a - e^3d}{b}\right)$	$\pi\,(ab - ed)$
	$0.06\,d^4$	$0.12\,d^3$	$0.866\,d^2$
	$0.06d^4$	$0.104\,d^3$	$0.866\,d^2$
	$0.007\,d^4$	$0.024\,d^3$	$\frac{\pi d^2}{8}$
	$\frac{bd^3 - h^3\,(b-t)}{12}$	$\frac{bd^3 - h^3 - (b-t)}{6d}$	$bd - h\,(b-t)$
	$\frac{td^3 + u^3\,(b-t)}{12}$	$\frac{td^3 + u^3\,(b-t)}{6d}$	$td + u\,(b-t)$
	$\frac{1}{3}\,[tc^3 + a\,(a-c)^3 - (a-t)\,(a-c-t)^3]$	I/c where $c = a - \frac{a^2 + at - t^2}{2\,(2a-t)}$	$t\,(2a-t)$
	$\frac{bd^3 - h^3(b-t)}{12}$	$\frac{bd^3 - h^3(b-t)}{6d}$	$bd - h\,(b-t)$

Fig. 1—Nomograph for finding maximum stress resulting from concentrated loading of cantilever beam

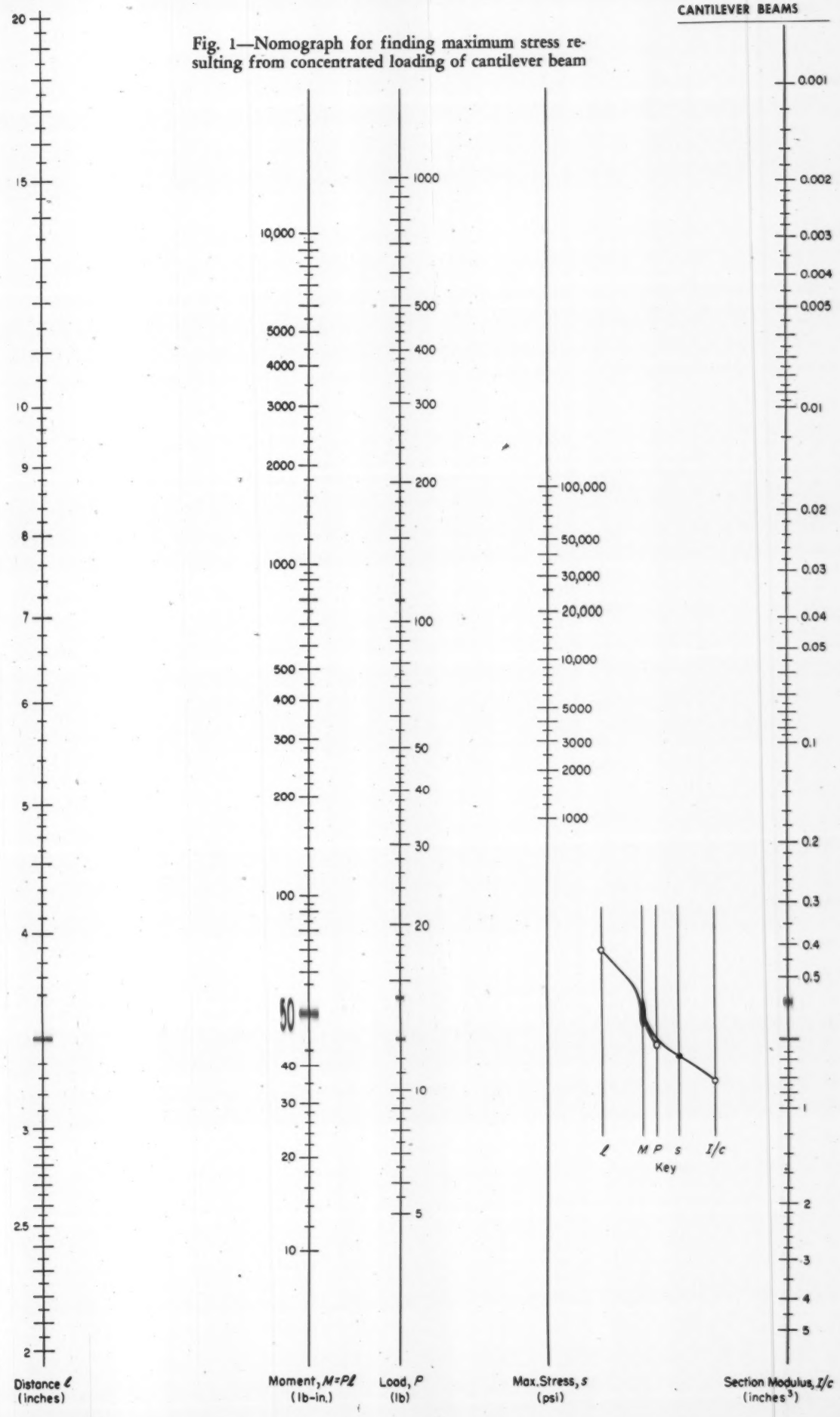
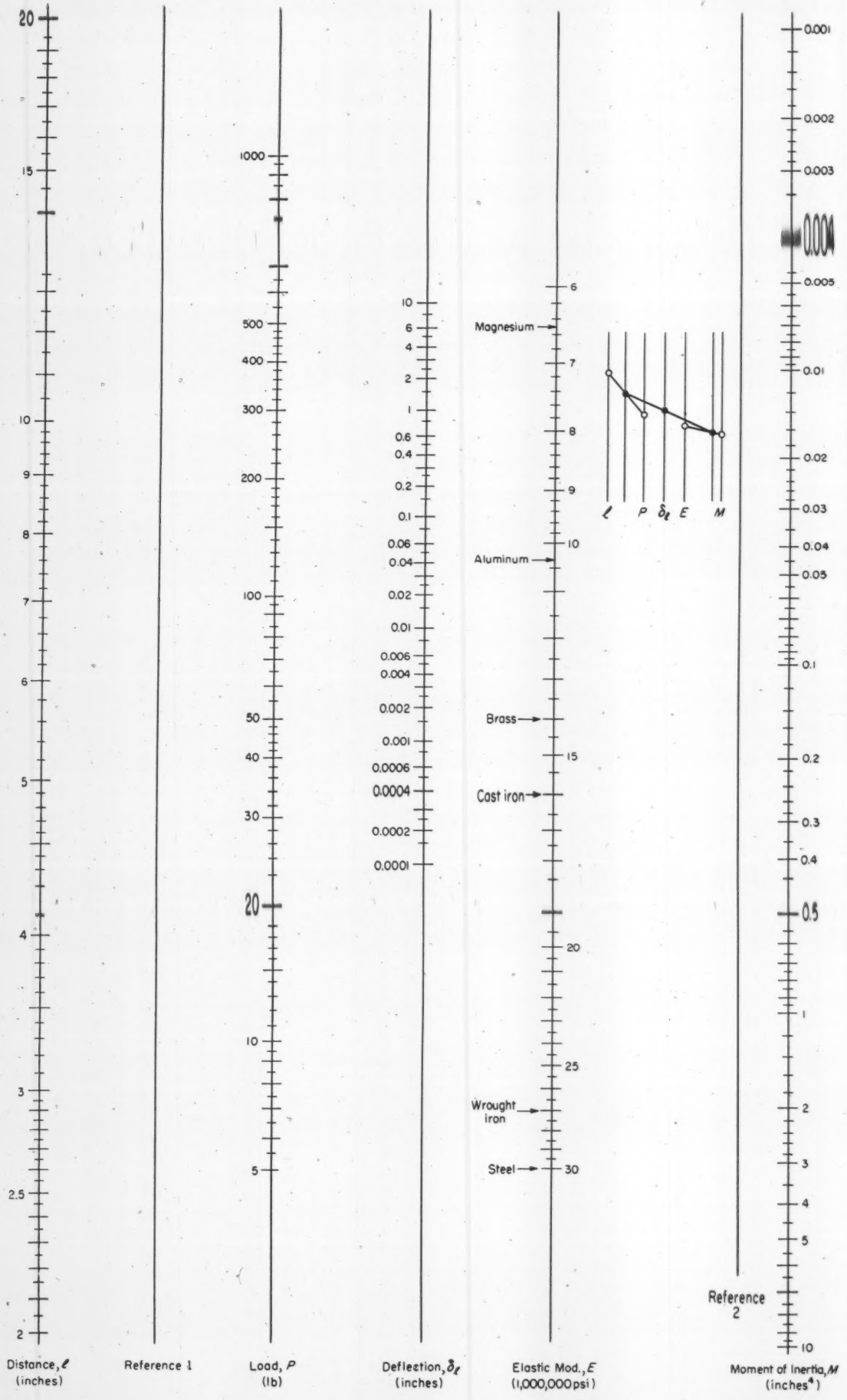


Fig. 2—Nomograph for finding deflection of cantilever beam at point of load application



Applications of

Thread and Form Rolling

By C. T. Appleton
Vice President
Reed Rolled Thread Die Co.
Worcester, Mass.

THREAD rolling is a simple cold-forging process confined almost entirely to external threads. Hardened steel dies are used to roll the threads. The threaded faces of these dies are pressed against the periphery of a plain cylindrical blank and reform the surface of the blank into threads as the blank rolls on the die faces. The working faces of the dies have a thread form which is the reverse of the thread to be produced. In penetrating the surface of the blank, the dies displace the material to form the roots of the thread and force the displaced material radially outward to form the crests of the thread. The blank has a diameter part way between the major and minor diameter of the thread.

A comparision of a cut and rolled thread is shown in *Fig.* 1. Unlike other threading processes, no material is removed and consequently no chips are produced.

Advantages of Rolled Threads: Rolled threads have relatively high strength, accuracy and degree of surface finish. They are uniformly produced at high rates of production with no wasting of material.

Increased Strength: Cold forging that threads receive during the rolling process strengthens them in tension, shear and fatigue.

When a thread is rolled, the fibers of the material are not severed, but are reformed in continuous unbroken lines following the contours of the threads, as in any good forging.

Rolling between smooth dies leaves the thread with smooth

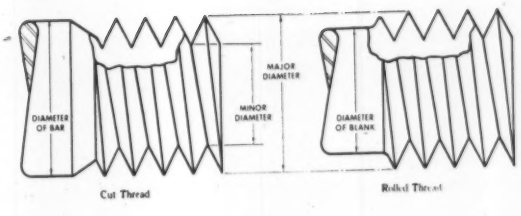


Fig. 1 — Comparison of cut and rolled threads

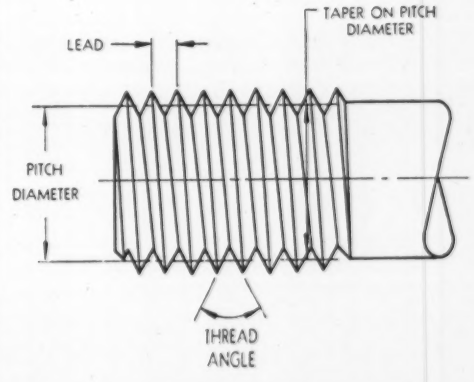


Fig. 2 — Elements controlled by pitch-diameter tolerances

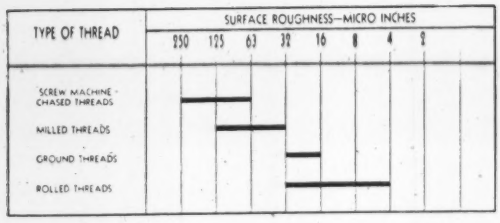


Fig. 3 — Comparison of common thread finishes

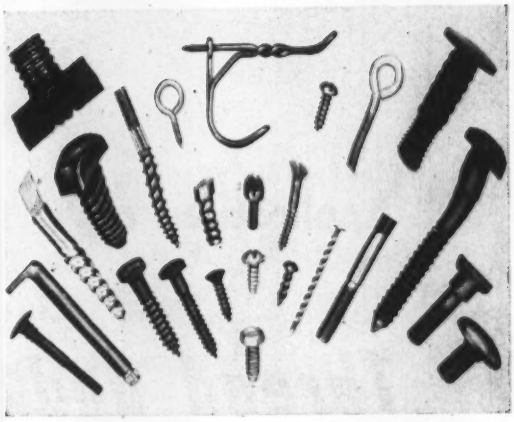


Fig. 4— Parts with straight and gimlet-point threads, knurling and other rolled forms

burnished roots and flanks, free from tears, chatter or cutter marks that can serve as focal points of stress and, therefore, starting points for fatigue failures.

Rolling also leaves the surface layers of the thread, particularly those in the roots, stressed in compression. These compressive stresses must be overcome before the tensile stresses can be built up which, alone, can cause fatigue failures.

Improved fatigue strength is reported to be on the order of 50 to 75 per cent. On heat-treated bolts from 36-40 Rockwell C hardness, with threads rolled after heat-treatment, tests show increased fatigue strength of 5 to 10 times that of cut threads.

Material Savings: Where blanks are prepared by heading, extruding or stamping, or where the thread is the largest diameter on the part, as in the case of a stud, rolling will save material. This results in savings ranging from about 16 per cent on larger diameter threads to over 27 per cent on smaller diameter threads. On stampings, the thickness of metal from which the stamping is made can often be

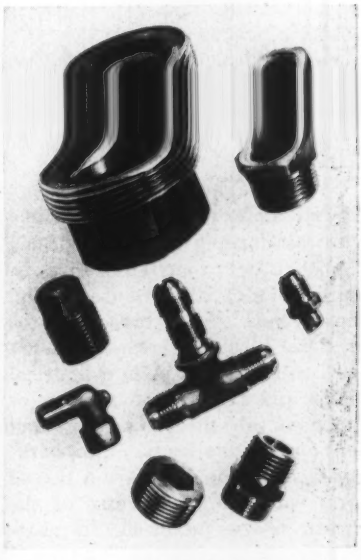


Fig. 5 — Pipe fittings with straight and tapered threads, Including ANPT and dryseal

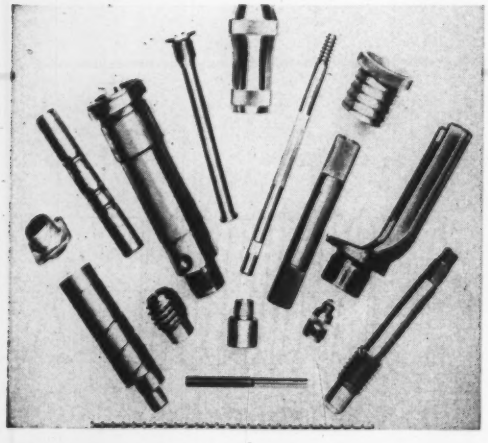


Fig. 6—Component parts with precision threads, serrations, grooves and burnished surfaces

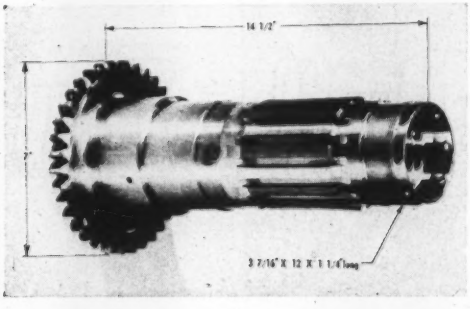


Fig. 7—Large, hollow aircraft part

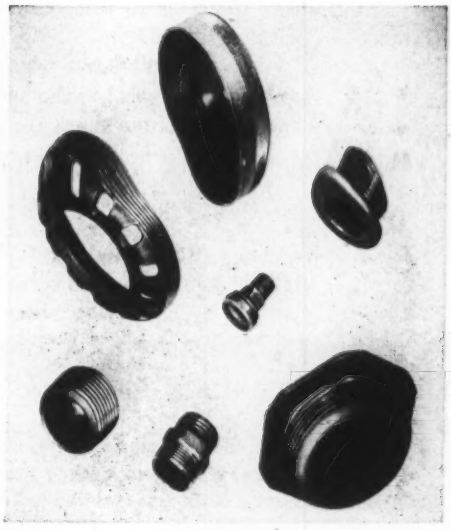


Fig. 8 — Metal stampings with rolled threads and forms

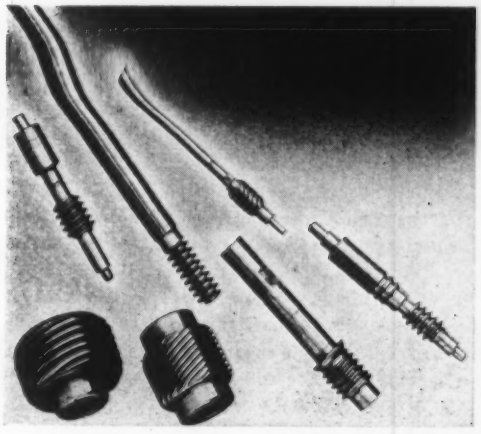


Fig. 9—Worms with rolled threads

reduced. This also reduces the weight of the scrap strip or sheet from which a stamping is made.

Accuracy and Uniformity: Production of accurate threads normally requires that close control be exercised over pitch diameter, thread angle, lead, taper, roundness and drunkenness (inequalities of pitch or helix angle). Tolerances specified for pitch diameter include all errors of pitch diameter, lead, thread angle and taper as shown in *Fig.* 2.

Thread angle produced on the work is dependent upon the accuracy of the thread-rolling dies, while accuracy of the lead produced is dependent upon accuracy of the dies and material being rolled. In most cases, lead of the thread on the die is exactly reproduced on the material rolled.

There are a number of reasons why it is inherently easy to achieve accuracy on pitch diameter, thread angle, lead and taper by rolling and, what is often equally important, to maintain that accuracy over long periods.

Thread form of a set of thread-rolling dies is faithfully reproduced on the parts, and does not change appreciably during the entire life of the dies. Thread-rolling dies do not wear out in the same manner as do other threading tools. Wear, instead of being concentrated on a sharp cutting edge, is distributed over a broad surface, and the rolling action is relatively free from friction. Therefore, the thread form of a rolling die is not changed by erosion, or does it fail to reproduce itself because of dullness or adhesion. It cannot be altered by improper sharpening, since sharpening is never required.

Smooth Finish: In cold-forming operations, surface finish left on the work is a close approximation of the surface finish of the dies. This holds true in the case of thread rolling except that the threads produced are ordinarily smoother than the dies or rolls. This improvement is accounted for by the slight slipping and burnishing that the thread always receives as it rolls against the dies.

A comparison of thread finishes commonly produced by the various threading methods is shown in *Fig.* 3.

Versatility: Thread rolling is capable of forming a wide variety of threads on many different materials and, in addition, capable of performing several nonthreading operations. Examples of the versatility of application are illustrated in *Figs.* 4 through 7.

Types of threads that can be rolled include standard, special, multiple, piloted, step, right or left-hand, nonuniform lead, socket and tapered, including pipe threads.

Nonthreading operations include rolling of oil grooves and annular rings, burnishing, knurling, splines and serrations. Crimping can be performed, as well as threading of hollow parts, die castings and irregular shaped parts.

Threads on metal stampings can be rolled easily due to the ductility of the material used in the stampings, *Fig.* 8. In many instances, thinner metal can be used because the diameter of the portion to be threaded need only be made to the approximate pitch diameter of the thread without making any reduction to the corresponding inside diameter of the stamping.

Worms with rolled threads provide quieter worm drives with longer life, *Fig.* 9. Burnished finish on the rolled thread increases the life of mating gears where nonmetallic gears are used. In many instances, heat-treatment of the worms has been eliminated since the rolled threads have smooth work-hardened surfaces.

Preferred Forms for Rolling: Whenever a material is penetrated

by a thread-rolling die, a volume of the material is permanently reformed.

A die having a relatively sharp crest penetrates a blank easier. The particles of material that are pressed down by a narrow crest flow easily away from that edge and along the surfaces of the flanks of the thread form. Particles a short distance away from the thread surface of the die have little or no distortion. Therefore, when rolling threads or other forms with wide root flats, it is desirable, where possible, either to round the edges of the root flat with as generous a radius as possible, or design the thread with a full-radius root. These rounded surfaces on the crests of the threads on the die streamline the flow of the material and provide an easier entering action of the dies into the blank.

American Standard and similar thread forms with narrow root flats roll easily. Threads for lag screws, wood screws and tapping screws have wide root flats and are usually rolled with flat dies specially designed to start the penetration with a narrow flat, and then gradually enlarge the width of flat to size.

Blank Design and Specifications: For common fasteners, such as bolts, cap screws and machine screws, blanks are usually cold-forged in heading machines. Close blank tolerances are maintained with carbide heading dies. Many parts are prepared for rolling on screw machines with the use of shaving tools. For very accurate threads with high hardness, blanks are usually centerless ground.

Ends of blanks should be beveled to prevent excessive chipping of threads on the dies or rolls. The angle and depth of bevel are important. A bevel of 30 degrees from the axis of the blank, which gives 60 degrees included angle, is preferred for general conditions. Diameter at the small end of the bevel should be less than the minor diameter of the thread.

In general, blank diameters should be less than the maximum pitch diameter of the thread and blank-diameter tolerances should be as small as practical for economical manufacture. On shorter thread lengths, especially with very soft materials, there is some endwise stretching of the blank. To offset this and obtain sufficient radial displacement of the material it is necessary to increase the blank diameter to compensate for endwise stretching.

Since rolling does not remove or compress material, the blank should not contain more than the correct amount of material to form the finished thread. Also, the dies must be set up so they will roll maximum major and pitch diameters when using a maximum-diameter blank. Otherwise, the blank will be overrolled and the dies will become overloaded.

Variation in the diameter of the blank results in variation in the major diameter of the thread when the dies are set in a fixed position. Blank diameter tolerances must therefore be controlled according to the accuracy of the thread to be produced.

Diameters from 0.060-inch to over 4 inches can be readily rolled on existing equipment, and special equipment for both larger and smaller threads can be developed when required. Threads per inch ranging from 2 to 80 are being rolled, and dies for both finer and coarser threads can be produced.

From a paper of the same title presented at the ASME Semiannual Meeting in Boston, Mass., June 1955.

Characteristics and prevention of

Fretting Corrosion

By R. B. Waterhouse

Department of Colloid Science
University of Cambridge
Cambridge, England

FRETTING corrosion may be defined as the forms of damage which arise when two surfaces in contact, and nominally at rest with respect to each other, experience slight periodic relative movement. It has been used to cover instances where the damage is partly due to chemical action and those where the damage is purely physical and the detritus is metallic. As such it may be regarded as a particular form of wear, although the circumstances in which it occurs differ in two important respects from those of ordinary wear. First, the relative velocity of the two surfaces is very much lower in the case of fretting corrosion. For example, assuming the motion is simple harmonic with an amplitude of 0.0001-inch and a frequency of 50 cycles per second, the maximum velocity is 1.8 inches per minute and the average velocity 0.6 inch per minute. Second, the surfaces are never brought out of contact and therefore there is little opportunity for the products of corrosion to escape.

Occurrence: One of the places in which fretting corrosion is most frequently found in heavy machinery is where a hub or bearing housing is press-fitted onto a shaft. As the loaded shaft rotates, the surface experiences alternating tensile and compressive stresses which are sufficient to cause slight movement between it and the hub. In the automobile industry, it has been found between the leaves of laminated springs and also in the races of ball bearings of cars that have been transported by road or rail. The roller bearings of heavy gun mountings on tanks and warships are also prone to fretting corrosion. In the aircraft industry

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it has occurred between the plates of bolted or riveted assemblies and at the edges of lugs carrying locating pins. In many of these instances small cracks are found to originate from the fretted regions at the edge of the hole.

Damaging Results: If the detritus can escape from the damaged area the removal of material from the two surfaces causes a loss of fit between them. On the other hand, if the detritus cannot escape, and if it is more bulky than the material removed, the system may seize. In an application where the two parts are occasionally called upon to move, for example, in a safety valve or governor, seizure can be very serious. The type of pits that are formed can initiate fatigue cracks, behaving in the same way as notches in the surface, and acting as stress raisers. In electrical gear it leads to poor electrical contract and in certain applications to distorted signals.

Fretting Corrosion and Fatigue: That areas of fretting corrosion are often associated with fatigue cracks is well known. Clearly, since fretting corrosion is conspicuous while cracking often remains hidden, the existence of fretting should be regarded as a warning that it is desirable to look for cracks if fatigue conditions exist. To say that fretting is necessarily the cause of fatigue cracks would be incorrect. It is better to say that conditions which favor fretting are often those which favor fatigue.

Preventive Measures: Chief factors in fretting corrosion are existence of periodic relative motion between two surfaces and corrosive action of the environment. Methods of preventing fretting corrosion are generally applicable where fatigue is likely to occur. It should be remembered, however, that certain treatments such as anodizing are themselves known to reduce fatigue strength.

Prevention of Relative Motion: Movement of surfaces occur when the tangential force exceeds the frictional force. It can therefore be eliminated by either reducing the tangential force, or increasing the frictional force. Since the latter is the product of the coefficient of friction and the normal load, there are two possibilities for increasing the frictional force. Where the design permits it, the simplest and most effective method is to increase the normal load. It is obvious that if the load is increased but is insufficient to prevent movement, the damage will be aggravated.

Frictional force may also be raised by increasing the coefficient of friction of the two surfaces. The method usually adopted is electroplating of the surfaces with a metal such as copper, tin, silver or gold. If, however, coefficient of friction is not high enough to prevent slip, the plated surfaces suffer fretting and are soon worn away. Much reliance is placed on cadmium plating as a protection against fretting corrosion in the aircraft and motor industries.

Movement may also be avoided by reducing tangential force. This can be achieved by covering one or both of the surfaces with a material of low elastic modulus, so that for a given amplitude of motion the tangential force does not reach the limiting value of the friction force. In that way the movement remains entirely within the interposed layer. The effectiveness of electroplated coatings is in part due to this property. Rubber gaskets have also been used in this way and found particularly successful.

Reducing Coefficient of Friction: Where there is difficulty in preventing relative motion it may be best to go to the other extreme and encourage movement of a frictionless character. Theories of friction involve damage to the sliding surfaces. Reduction of the coefficient of friction therefore implies reduction of this damage. Lubrication with fluids is generally not effective in reducing fretting corrosion because the sliding speeds are low. The addition of a boundary lubricant never completely prevents metal-to-metal contact and therefore the conditions for fretting are still present. They may, however, have a secondary function once fretting has started, by acting as dispersing agents for the debris. Whether this is beneficial or harmful depends on the nature of the debris, that is, whether it is an abrasive or whether it can provide a cushion between the surfaces. Lubricants, however, have shown more promise when applied to metal surfaces with a nonmetallic coating which can act as a reservoir for the lubricant.

Greater success has been achieved with solid lubricants. When molybdenum sulphide was applied to steel surfaces by baking, the onset of fretting in tests was postponed for 28×10^6 cycles. Whether this would be adequate in practice must depend very much on the particular conditions. Addition of molybdenum sulphide to a liquid lubricant has little effect.

Investigations have shown that there is no fretting between a steel and a polytetrafluoroethylene surface. The coefficient of friction of this material against steel is 0.06.

A third type of low-friction coating that has proved successful in the laboratory in preventing fretting is lead plating. Indium has also been recommended in this connection. This is an application of a form of lubrication which exploits the low shear strength of these metals.

Chromium-plated surfaces are reported to have a low coefficient of friction and to be affected by adsorption of the lubricant in the inevitable cracks in the plating, but chromium plating has not been successful in preventing fretting.

Increasing Abrasion Resistance: In experiments utilizing a series of steels of increasing hardness it has been found that the harder the steel, the smaller the fretting damage. Increasing the hardness of the surface is beneficial in two ways. It lessens the tearing of the surface due to welding because the work-hardened material at the weld will not be very different from the bulk of the material, and any welds that are formed are more likely to break at the original junction. If debris is formed it will be of a

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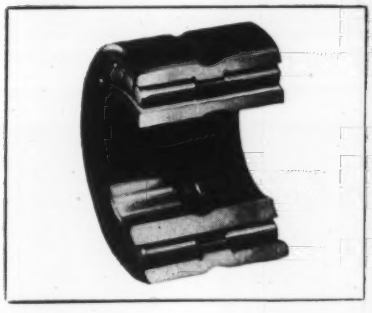

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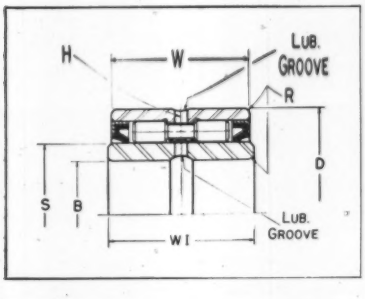

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smaller particle size and the hard surface will suffer less by abrasion.

Case hardening and nitriding have some effect in improving fatigue strength in a test where fretting is present, but how much of this is due to the reduction of fretting and how much to the improvement of the fatigue strength itself is uncertain.

Chromium plating, which is sometimes applied where a hard surface is required, has generally proved unsuccessful in allaying fretting, no doubt owing to the hardness of its oxide.

The second type of abrasive-resistant coating is the oxide or phosphate coating such as that produced by anodizing aluminum or Bonderizing steel. Phosphate coatings have been successful in preventing wear on pinion gears, universal-joint trunnions, valve stems, pistons and cylinder bores. Anodized and phosphate coatings are most satisfactory in preventing fretting when impregnated with a lubricant.

Abrasion by oxide debris may be reduced by giving it every opportunity to escape. This may be realized by roughening the surface or by improving the supply of liquid lubricant.

Exclusion of Atmosphere: Although experimental evidence indicates that some damage still occurs in vacuum or in a protective atmosphere, the severity of fretting is much reduced. In practice the atmosphere can be excluded to a certain extent by flooding the surfaces with a lubricant in which oxygen has a low solubility and diffusivity. Rate of fretting has been reduced by a factor of 200 in the presence of liquid paraffin. Improvement in the supply of lubricant by providing more channels to the fretting surfaces has prevented fretting. The excellent property of a rubber gasket in preventing fretting, mentioned previously, is attributed in part to the way in which it molds itself to the contour of the surface and thus prevents access of air.

Distance of Separation: An obvious method of preventing fretting is to separate the two surfaces which are in contact. Very occasionally it may be possible to separate them completely by changing design, but in general this is not a practicable solution. Several of the methods which have been mentioned could be regarded as acting solely as a means of separating the surfaces, for example, improved supply of lubricant, preferably under pressure, or nonmetallic inserts between the surfaces. However, separation by such inserts may not necessarily be effective since it may merely result in fretting between the insert and the two metal surfaces. Phosphate or anodized coatings may also be regarded as acting as separators, although here again the site of fretting may be transferred to the surfaces of the coating.

From a paper entitled "Fretting Corrosion" presented at the Institution of Mechanical Engineers, London, England, 1955.

Design Factors for Brass-Powder Parts

By G. L. Werley

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New Jersey Zinc Co.
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PRACTICALLY all metals can be made into powders, but those most widely used for powder metallurgy today are iron, copper (largely mixed with tin to produce bronze) and brass. Brass was a late starter in the field of powder metallurgy and, consequently, the qualities of this powder for the pressing and sintering of structural parts are not so well known as those of some of the more firmly established metals.

The bulk of brass-powder compacts are in the under 4-inch diameter size range. Lower limit on minimum wall thickness or diameter is about 0.030-inch.

While parts produced by powder metallurgy can be complex in shape to obviate the need for elaborate machining operations, it would be completely unrealistic to say that a part is a "natural" for the process simply because it is of intricate design. Like any other production method, powder metallurgy has limitations imposed by both the raw materials and the existing fabricating equipment. It is possible, however, to set down these basic shapes as being well suited to production as brass-powder parts.

Parts well suited to brass-powder production include:

1. Cylindrical, rectangular or irregular shapes which are relatively thick (up to 1 inch) and which, in general, do not involve large variations in cross-sectional dimensions, and do not have a length-to-diameter ratio exceeding 2½ to 1.
2. Parts with surface indents or projections on tops or bottoms.
3. Parts with simple flanges or projections at one end.
4. Parts with splines, gear teeth or knurling.
5. Parts with holes, counterbores, slots or keyways.

It is good practice in designing brass-powder structural parts to avoid the following:

1. Narrow or deep splines.
2. Feather edges.
3. Sharp corners at the junction of the flange and body on flanged parts and other stepped designs.

Normally it is impractical to produce powder parts having undercuts (annular grooves, screw threads, flanges at both ends, etc.) since, among other things, such parts are difficult to remove from the die cavity. Undercutting and other machining operations, such as drilling and tapping, can be performed easily and economically on brass-powder parts, particularly on those which are formed with leaded brass.

From a paper entitled "An Evaluation of Brass-Powder Structural Parts in Product Engineering" presented at the ASME Spring Meeting in Baltimore, Md., April 1955.

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...AMPCO* Metal improves its high physicals, retains ductility (does not become brittle) — even at extreme low temperatures

Its ability to perform dependably under conditions of extreme cold without becoming brittle is one of Ampco Metal's more unique properties—but one, nonetheless, that really pays off for designers of Arctic equipment, above-the-atmosphere missiles, gas liquefying machinery, and similar applications. Tests made with Ampco Metal to temperatures as low as –400° F. show that it remains ductile, retains its high mechanical values, even at this brutal, machine-punishing cold.

But the Ampco story doesn't stop there. This series of remarkable alloys gives you high strength-to-weight ratios — tensiles to 110,000 psi with 10 to 15 percent less weight than ordinary bronzes. It combats all forms of wear — sliding wear, erosion, corrosion, fatigue.

All the advantages of one of the world's most versatile metals are yours when you specify Ampco Metal. Get full information from your nearby Ampco field engineer or write us.

AMPCO®

Sole Producer of Genuine Ampco Metal

AMPCO METAL, INC.

Dept. MD-1, MILWAUKEE 46, WISCONSIN • *West Coast Plant:* BURBANK, CALIFORNIA

*Reg. U. S. Pat. Off.

W-136

—ITEM 191—

For More Information Circle Item Number on Yellow Card—page 19

HELPFUL LITERATURE
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Magnetic Laminations

"Performance Guaranteed" is title of illustrated catalog ML 201 on lines of laminations, laminated cores and dies. Specification sheets show individual laminations to scale as well as properties of square cross-section core stacks, and weights and counts for different materials. Progressive tungsten carbide and tool steel dies for production runs of laminations are described. 20 pages. Magnetics, Inc.

—Circle ITEM 1

Armored Tubes

Armored group of long length tubes twisted together to permit bending without distortion is subject of illustrated bulletin. Multitube has galvanized steel or polyvinyl chloride sheath, or combination of both, containing copper, aluminum polyethylene or soft steel tubing in sizes from ⅛ to ½-in. Assemblies have from 1 to 37 tubes. 8 pages. Crescent Insulated Wire & Cable Co.

—Circle ITEM 2

Wire Construction

"How Wire Construction Reduces Costs," is title of booklet which compiles 36 illustrated case histories covering applications such as motor mounts, fan guards, furniture, building specialties and television components. Before and after photos point up cost cuts in material, production and tooling; reduced weight; simplified design; improved appearance; and noise and vibration reduction. 12 pages. E. H. Titchener & Co.

—Circle ITEM 3

Powder Metal Brass Alloys

Chemical composition of series of Sintaloy Z powder metal brass alloys, plus essential physical properties and characteristics are found in technical sales bulletin. 1 page. Dixon Sintaloy, Inc.

—Circle ITEM 4

Electric Brakes & Clutches

Folder type application analysis report pictures and describes 21 of the many ways in which standard Warner brakes and clutches can be applied to power transmission drives. Use in agricultural machinery, machine tools, packaging machinery, textile machines, welding equipment, molding machines and printing equipment is covered. 8 pages. Warner Electric Brake & Clutch Co.

—Circle ITEM 5

Aluminum Pipe

Everything from air to acid can be conveyed through aluminum pipe described in illustrated booklet "Aluminum Pipe & Fittings." Characteristics, advantages and specifications are given and methods of installation are described. Covered are machining, welding, use of supports, thermal insulation and methods of protection. 16 pages. Aluminum Co. of America.

—Circle ITEM 6

Swaged Hose Assemblies

Line of Weatherhead swaged hose, hose ends and adapters available through Assembly Service offered by distributors is shown in illustrated catalog S-1. Hose assemblies of any size, type, length, pressure and quantity can be ordered. An assembly numbering system is detailed. 8 pages. Weatherhead Co., Fort Wayne Div.

—Circle ITEM 7

EP Lubricants

Seventeen types of molybdenum disulfide lubricants are listed in revised bulletin 103A. Importance of compounds in extreme bearing pressure, and high, low and normal temperature lubrication applications is discussed. Selector chart describes each type, its carrier, temperature range and method of application. 4 pages. Alpha Molykote Corp.

—Circle ITEM 8

Thrust Retainers

Information on thrust retainers and washers offered in this folder covers selection, uses, advantages, installations, lubrication and dimensions and thrust capacities. Retainers are made with many types of balls, including chrome alloy, stainless steel, brass or nylon. 4 pages. Hartford Steel Ball Co.

—Circle ITEM 9

Stresses in Steel Bars

"Residual Stresses in Cold-Finished Steel Bars and Their Effect on Manufactured Parts" is a pocket-size illustrated booklet which specifically covers cold drawn, turned and ground bars and heat treated steel. Fatigue, cracking, machinability, tolerances and corrosion are discussed. 32 pages. La Salle Steel Co.

—Circle ITEM 10

Which Scale for Weighing?

Types of scales, weighing machines and attachments, and relative advantages, limitations and recommended uses for each are detailed in illustrated brochure "Which Scale for Your Weighing Job?" Units for weighing, counting, sorting, batching and keeping printed records are covered. 16 pages. Materials Handling Laboratories, Inc.

—Circle ITEM 11

Permanent Magnetic Equipment

Line of permanent magnetic equipment designed for conveying and controlling steel and separating, retrieving and purifying ferrous materials is subject of illustrated brochure B-207. Specifications of units are presented. 6 pages. Eriez Mfg. Co.

—Circle ITEM 12

Adjustable Speed Drive

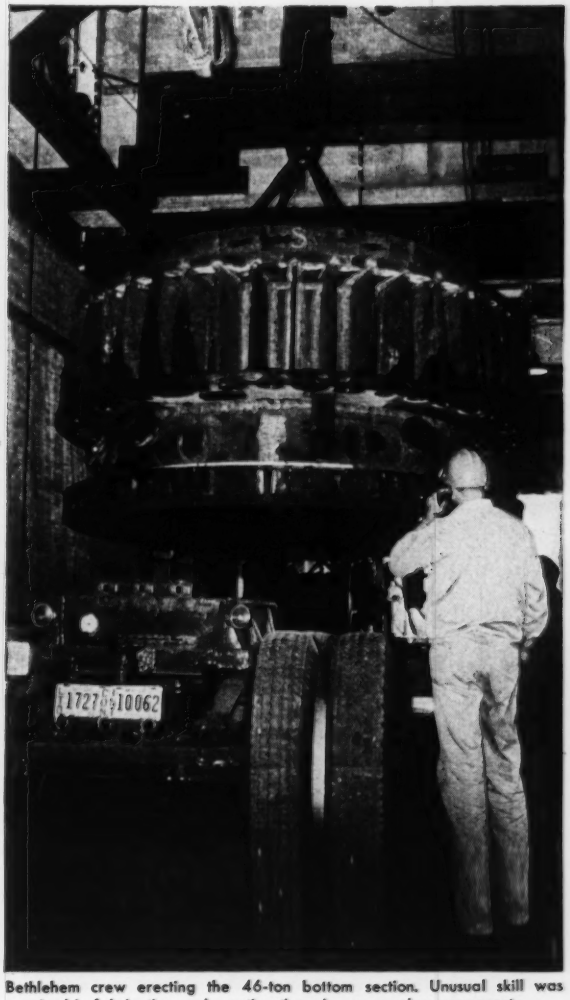
Use of Ampli-Speed magnetic drive for fan type (centrifugal fans, pumps, compressors) and constant torque loads (conveyors, mixers, machine tools) is outlined in illustrated bulletin. Construction features of adjustable speed unit are given. Ratings, speed ranges and other data are given. 4 pages. Electric Machinery Mfg. Co.

—Circle ITEM 13

Carbon Resistors

Wide range of standard RETMA ohmage values are available in Electroseal deposited carbon resistors, produced in 1/20, 1/10, ¼, ½, ½, 1 and 2-w sizes. High frequency re-

Machining the 18½-ton top section which provides a 4-ft opening for charging the McDonald Digester. A complex door was installed later.



Bethlehem crew erecting the 46-ton bottom section. Unusual skill was required in fabricating and erecting these huge, complex components.

New Pulpmaking Process Uses 187-ton Welded Digesters

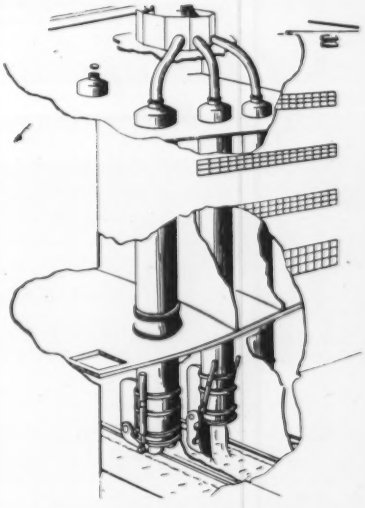
How to make satisfactory pulp from hardwoods has long challenged the paper industry. This problem has been solved by Great Northern Paper Company with the recent construction of a chemi-groundwood pulp mill at East Millinocket, Me.

The heart of chemi-groundwood pulping is a battery of four big digesters, fabricated and erected by Bethlehem, each 10 ft in diameter and 64 ft high. Debarked hardwood logs are cooked in a sulphite liquor in the digesters at pressure of about 150 p.s.i. and temperatures up to 310 deg F. After eight hours the logs are soft and pliable.

The digesters, all ASME Code vessels, were fabricated chiefly from rolled plates of A-212 Grade B steel. They were stress-relieved and hydrostatically tested after fabrication, and the welds were radiographed.

The bottom doors, giant circular forgings 12 in. thick and over 14 ft in diameter, weigh 40 tons each. They are operated by twin hydraulic lifting cylinders and are held in position by 42 bolts, all hydraulically operated.

Unusual as they are, these digesters illustrate the type of custom fabrication which Bethlehem is well equipped to handle. Our nearest sales office will gladly give you further information about Bethlehem's fabrication of weldments for an exceptionally wide range of industrial applications.



Cutaway drawing shows installation of digesters. Stone & Webster Engineering Corporation, Designers and Constructors.

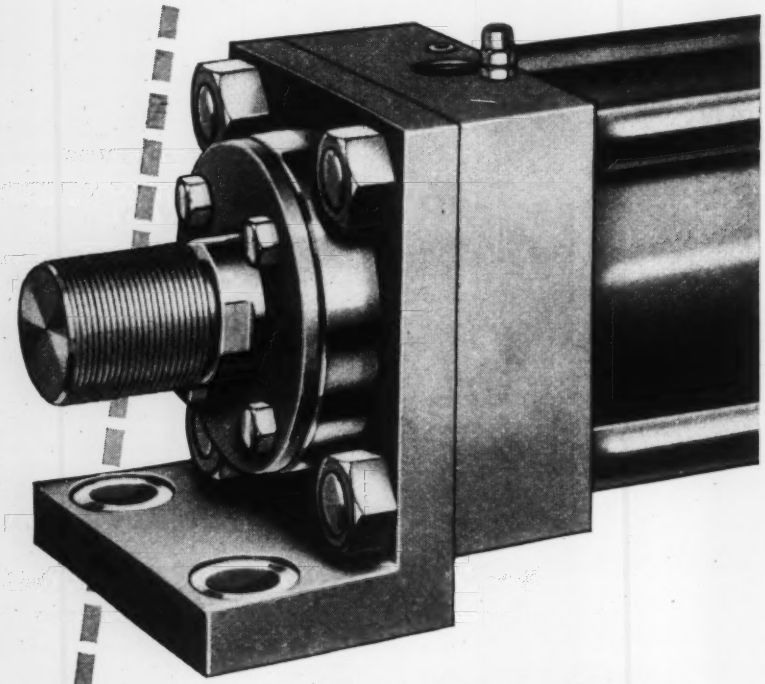
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

consistent dependability



H-P-M Job-Proved Cylinders Assure Uninterrupted Performance

H-P-M cylinder construction deserves your close examination—here's a line that's built to take it. We know—we've used them on our own heavy press equipment for years. They're without equal for strength, precision and power. You'll appreciate the solid steel covers for safety, efficient rod packings and hydraulic seals, the accurately machined bore and automotive type piston—just a few of the outstanding features of H-P-M cylinders. Over 700 types . . . sizes to 12" bore . . . 150 (air), 300, 2000, and 3000 psi lines. Get the facts from your nearby H-P-M representative or write today for complete information. H-P-M also manufactures a complete line of hydraulic pumps, valves, controls and power units.

HYDRAULIC POWER DIVISION
THE HYDRAULIC PRESS MFG. CO.
Mount Gilead, Ohio, U.S.A.

HPM

Helpful Literature

sponse and temperature coefficient curves, plus other data, are included on illustrated data sheet. 2 pages. Electroseal Products, Inc.

—Circle ITEM 14

Universal Joints

Plain and needle roller bearing styles of Almetal universal joints are described and illustrated in folder "Almetal Universal Joints & Drive Shafts." Capacities range up to 100 hp at 550 rpm and swing angles are 20, 35 or 90 degrees. 4 pages. Detroit Bevel Gear Co.

—Circle ITEM 15

Steel Tubing

Various types of steel tubing, including seamless or welded stainless, alloy and carbon steel types, are described in illustrated bulletin TB-408. Analyses, properties and creep strengths of available types are given. References to more detailed literature are included. 8 pages. Babcock & Wilcox Co., Tubular Products Div.

—Circle ITEM 16

Stainless Properties

Blue data sheet on chromium-nickel-molybdenum stainless steel types 316, 316L, 317 and 317L provides details on various mechanical and strength properties of these steels. Allegheny Ludlum Steel Corp.

—Circle ITEM 17

Motors & Drives

Photos and information on special and standard motors and adjustable speed drives are contained in brochure "Motors & Drives for the Machine Tool Industry." Data on over 15 motors and drives and a number of installations are in it, along with technical data on electrical features. Louis Allis Co.

—Circle ITEM 18

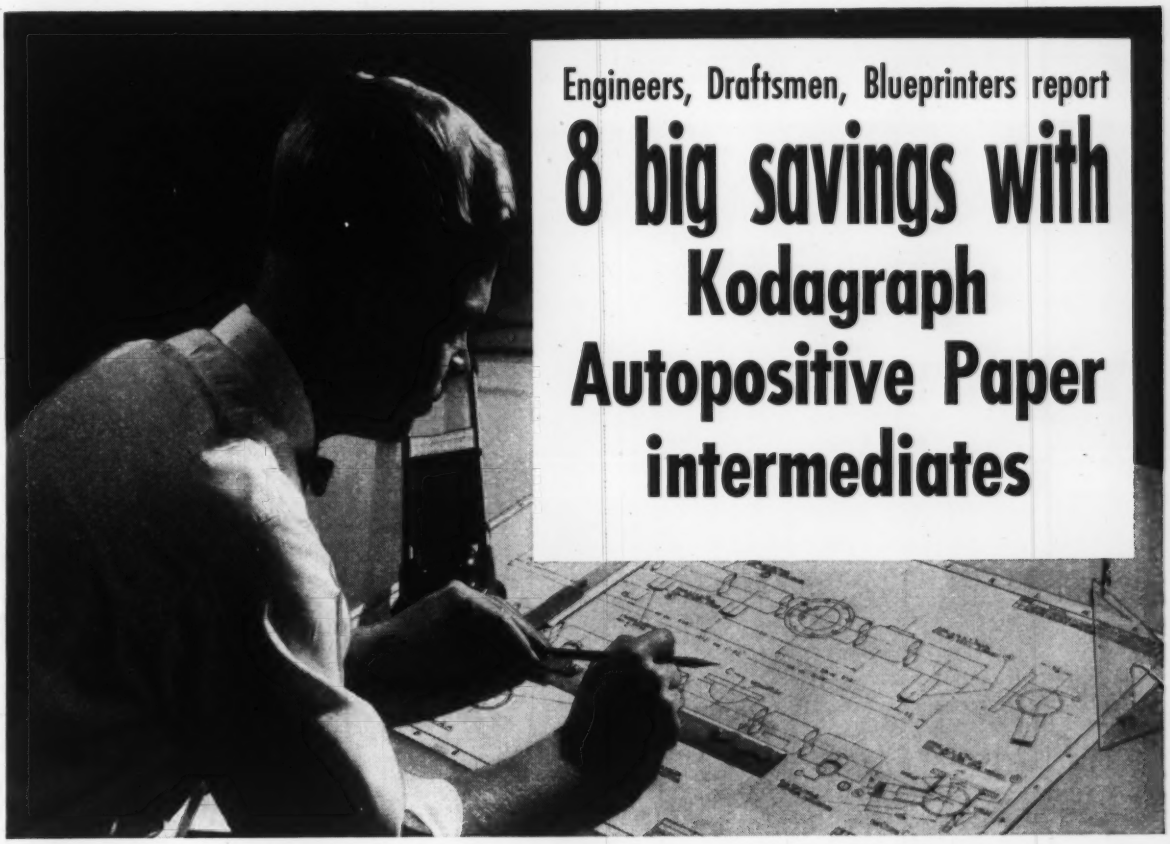
Fastener Data

Thumb indexed for easy reference, illustrated stainless fastener data book covers thread and size specifications and availability of 40 basic screws, bolts, nuts, washers, rivets and other fasteners. Engineering data on composition, properties, applications and weights is also provided. 52 pages. Allmetal Screw Products Co.

—Circle ITEM 19

Solenoid Air Valves

Three illustrated bulletins cover Shear-Seal solenoid operated valves



Engineers, Draftsmen, Blueprinters report

8 big savings with Kodagraph Autopositive Paper intermediates

Revolutionary Kodagraph Autopositive Paper, which produces positive photographic intermediates *without a negative step or dark room handling,* brings these savings to drafting rooms large and small.

1. Protects original drawings. Low-cost Autopositive Paper intermediates are used instead of valuable originals in printmaking, reference, mailing, and making revisions.

2. Reclaims drawings which are old, worn, or soiled. Reproducing them on Autopositive Paper cleans up backgrounds, strengthens line detail . . . eliminates redrafting.

3. Improves legibility of prints. Blueprints or direct-process prints made from Autopositive Paper intermediates are consistently easier to read than prints made from original drawings.

4. Reproduces "unprintable" originals. When extra copies are needed of blueprints, drawings on opaque stock, two-sided originals, and other "unprintables," just reproduce them on Autopositive Paper *and you have your printmaking masters.*

5. Speeds revisions of drawings. A popular short cut is to cut out or eradicate detail on an Autopositive Paper intermediate . . . and then add the new detail to this print or one made from it.

6. Eliminates redrafting standard component designs. From a file of standard component designs made on Kodagraph Autopositive Film, select the ones needed and attach to drawing form with translucent tape. Then reproduce on Autopositive Paper, add new detail and the job is done.

7. Simplifies print distribution. Instead of shipping bundles of production prints, send Autopositive Paper intermediates. Mailing costs are saved. Required number of prints can be made at other end. No overstocking this way . . . or running short of prints.

8. Provides photo-lasting copies. Autopositive Paper intermediates, with dense black photographic lines on a translucent white paper base, will not turn yellow or become brittle in the files; will produce sharp, legible prints whenever needed.

New illustrated booklet gives full story on Kodagraph Autopositive Paper, which you, or your local blueprinter, can process readily with existing printmaking equipment and standard photographic processing.

Kodagraph Reproduction Materials

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N. Y.
Gentlemen: Please send me a free copy of your new booklet on Kodagraph Reproduction Materials. 19

Name_____

Position_____

Company_____

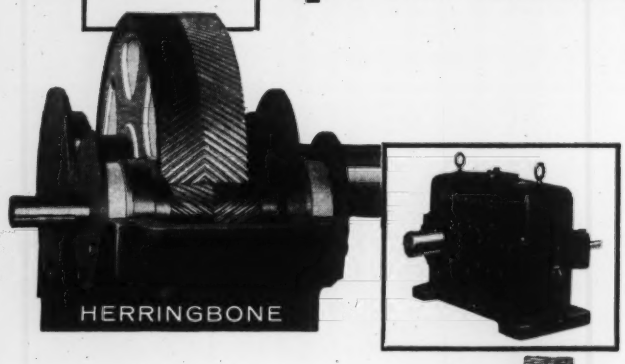
Street_____

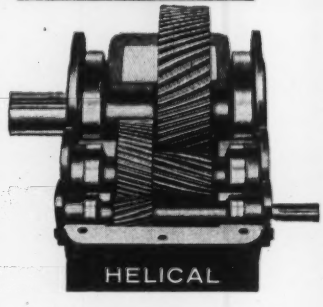
City_____

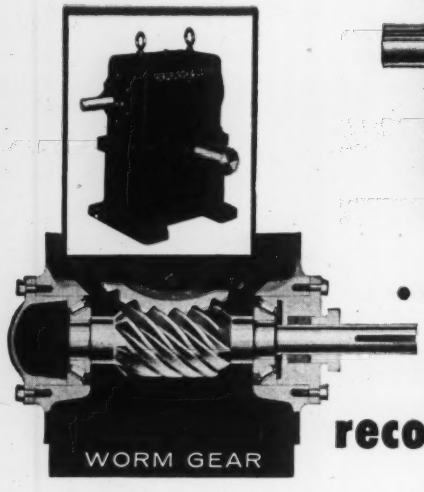
Zone_____ State_____

Kodak

3 H&S Speed Reducers







. . . assure *unbiased* recommendation

Each of these three general groups of H & S Speed Reducers has its particular mechanical advantages which make it more efficient for specific duties. There are many considerations, such as speed of driving and driven shafts, shape of housing and drive characteristics that must be considered for lasting reducer performance and economy.

With the complete H & S line of Speed Reducers to choose from, you can be sure of our unbiased recommendation and your selection of the right type reducer for each specific job.

H & S Reducers are available in single reduction units in ratios up to 100 to 1; in combination units up to 700 to 1; and in double reduction units up to 10,000 to 1.

Make H & S your source for *all* speed reducing requirements.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

Send note on Company Letterhead for complete H & S Catalog

—ITEM 195—

Helpful Literature

for air, oil and water. No. 5S-A covers air valves for 0-250, 1000 and 1500 psi; 5S-H covers oil valves for 0-250, 1500 and 3000 psi service; and No. 5S-W describes water valves for 0-250, 1500 and 3000-psi use. Characteristics, flow patterns and dimensions are given. 4 pages each. Barksdale Valves.

—Circle ITEM 20

Flexible Ball Joints

Many industrial applications for Barco flexible ball joints for piping are described and illustrated in catalog 215-B. Design permits 30 to 40-degree angular side flexing, plus 360-degree slow rotation. Engineering specifications and other data for sizes up to 12 in. are included. Various types of ends and insulated and jacketed joints are available. 20 pages. Barco Mfg. Co.

—Circle ITEM 21

Screw Machine Facilities

Company facilities for producing automatic screw machine products are reviewed in booklet, "Automatic Screw Machine Products." Capacity of screw machines ranges from ⅛ to 4½ in. diameter. Heat treating, brazing and welding, plating and anodizing, painting and assembly are also outlined. 8 pages. Harvey Aluminum, ASM Div.

—Circle ITEM 22

Rotary Valve Power Drive

Specs and installation data on 13 electro-automatic rotary type power valve drives is presented in illustrated brochure. Stressed features include mounted flanges separate from main housing, the Guardian cut-out and the all-in-one motor gear box housing design. 24 pages. Janette Electric Mfg. Co.

—Circle ITEM 23

Ceramic Magnets

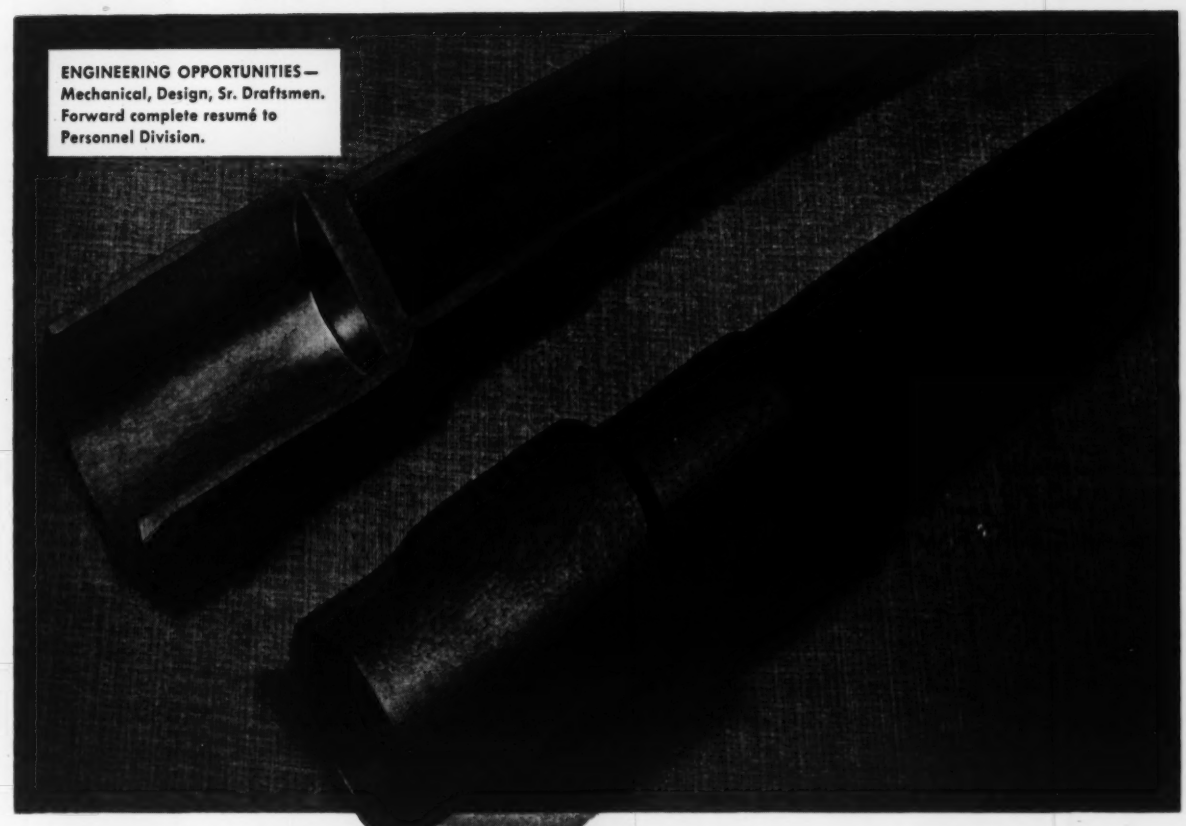
Characteristics, design and application of Index I lightweight, nonmetallic ceramic permanent magnet are brought out in catalog 15. Magnet is suitable for gages, magnetic coupling, magnetic filters as well as for generators, motors and TV focusing units. Experimental magnets available are listed. 4 pages. Indiana Steel Products Co.

—Circle ITEM 24

Hydraulic Pumps & Motors

Hydraulic pumps, motors, power units and accessories are subject of comprehensive catalog 601. Performance curves, dimension drawings

ENGINEERING OPPORTUNITIES—
Mechanical, Design, Sr. Draftsmen.
Forward complete resumé to
Personnel Division.

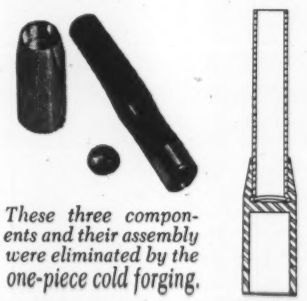


HUNTER DOUGLAS ONE-PIECE COLD FORGINGS

replace 3 piece unit, eliminate assembly, solve gas leakage problems!

A typical example of how Hunter Douglas cold forgings simplify everyday design problems

A most critical requirement in the production of an ordnance component was a perfect seal against the escape of high pressure gases. Fabrication by conventional procedures involved the assembly of three separate pieces—a screw machine part turned from bar stock and bored from each end; a separate sleeve machined from tubing, and a stamped Welsh plug. The three parts were unitized by expanding the Welsh plug within the sleeve, forcing walls into a machined groove within the head.



These three components and their assembly were eliminated by the one-piece cold forging.

To simplify the design, insure leak-proof construction and eliminate costly machining and assembly time, Hunter Douglas engineers suggested a cold forging from HD-11-T6, a high strength aluminum alloy.

All internal and external diameters of the cold forged component are now formed in a single, instantaneous press operation. No joints exist to cause leakage, consequently rejects are negligible. The cold forging, being highly stressed, easily withstands bursting pressures of 5500 psi without distortion. With its remarkable simplification in design, the cold forging requires fewer machining operations, thus saving both time and unnecessary metal waste.

Hunter Douglas Cold Forgings can be mass-produced in any required numbers and to cover a tremendous range of design requirements. If your components require *walls of zero draft, high physical properties, employ tubular shapes with or without a closed end, and must meet close dimensional tolerances,* HUNTER DOUGLAS COLD FORGINGS may provide the answer. Our engineers will give you a prompt analysis upon submission of a blueprint or sample part.

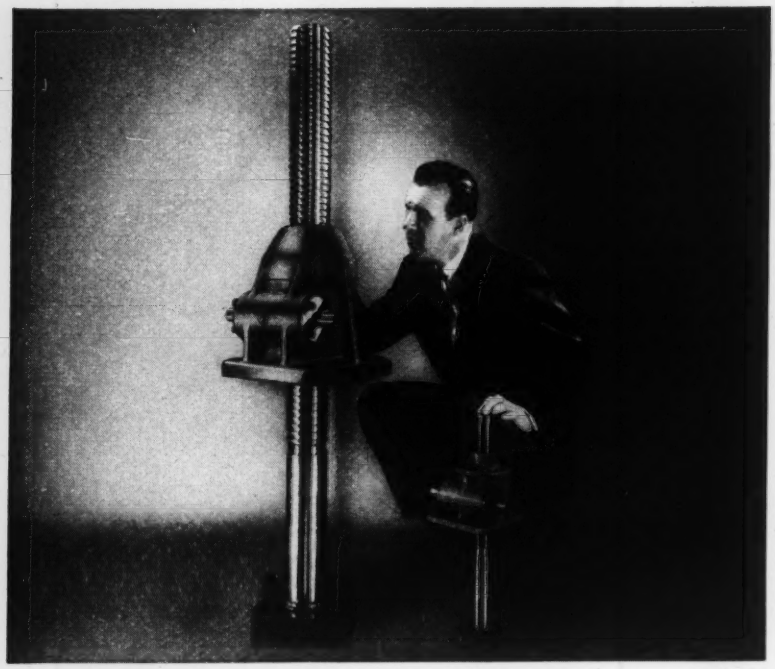
Hunter Douglas Cold Forgings cover a multitude of needs. Note wide variation in part geometry. Many complex designs formerly considered impossible to produce by cold forging now respond to new techniques developed at Hunter Douglas.

DESIGNERS:

If you want to know more about Hunter Douglas Cold Forgings write on your company letterhead for this free 40 page book, just off the press!

Hunter Douglas HD Corporation

HUNTER DOUGLAS CORPORATION • DEPT. MD-13 RIVERSIDE, CALIFORNIA TELEPHONE OVerland 3-3030

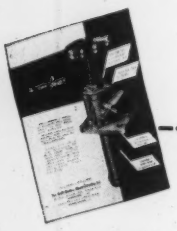


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes or any power-operated positive control system so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 35 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 96:1; turn of worm for each 1-inch raise, 10 to 180; available in either Acme or square threads. Screw ends and tops are available in many types and can be readily adapted to your specific requirements.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes or to your special order. For complete specifications and detailed drawings, send for your free copy of a special brochure.



DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME _____ TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

—ITEM 196—

Helpful Literature

and engineering data will help in equipment selection. Accessories covered include gages, pressure gage snubbers, flexible couplings, suction strainers and heat exchangers. 66 pages. Hydraulic Press Mfg. Co.

—Circle ITEM 25

Automatic Feeders

Elevating, blade, rotary and vibratory type automatic feeders which will make production machines fully automatic are described and illustrated in series of data sheets bound into catalog form. Feeders handle bolts, screws, bushings, valves, slugs, piston pins, tube fittings, forgings, gear blanks, studs and bars up to 30 in. long. 14 pages. Feedall Inc.

—Circle ITEM 26

Fluid Pressure Cells

SR-4 fluid pressure cells used in electrical measurement and control of pressure are presented in bulletin 4306. Six standard types in 25 sizes ranging from 15 to 50,000 psi, as well as some special purpose cells, are included. Characteristics, operating principles, instrumentation and specs are considered. 16 pages. Baldwin-Lima-Hamilton Corp.

—Circle ITEM 27

Aircraft Plumbing

Catalog 100 is an up-to-date reference source on flexible hose lines, detachable fittings, self-sealing couplings and other fluid-line products for aircraft applications. Engineering data is provided to help designers in fluid system planning, selection and installation of hose and fittings, assemblies and self-sealing couplings. 78 pages. Aeroquip Corp.

—Circle ITEM 28

Straight Line Strainer

Technical bulletin 240 provides flow chart on straight line strainer for pressures up to 150 psi. Strainer protects equipment, valves and controls by providing clean, unrestricted flow of fluids within supply line. 4 pages. Hays Mfg. Co.

—Circle ITEM 29

Speed Reducers

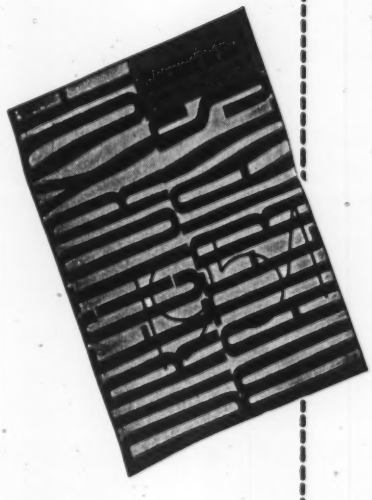
Individual sections of catalog 155 on line of speed reducers contain dimension and parts drawings, weights, shaft arrangements and ratings for each of 150 models. General engineering data to facilitate selection and application is included. 112 pages. Request on company letterhead from Winsmith, Inc., 27 Eaton St., Springville, Erie County, N. Y.

Get yours while the supply lasts!

MACHINE DESIGN's

DIRECTORY of MATERIALS

...the only directory of its kind available anywhere.



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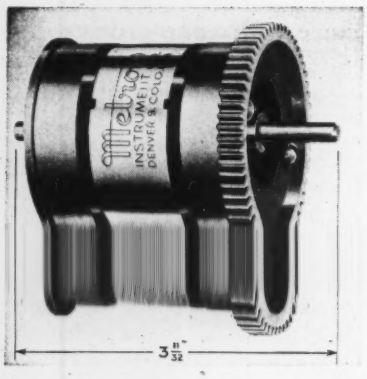
NEW PARTS AND MATERIALS

Use Yellow Card, page 19, to obtain further information

Miniature Differential

in ratios from 1:1 to 27:1

Line of miniature differentials combines two rotating inputs to provide speed sums or differences and angular sums or differences. Units also can be used for controlling relative speeds, for obtaining wide speed ratios between shafts, for shifting phase angles between rotating shafts, and for reversing and changing speeds quickly without disconnecting the power source. Thirty-four different ratios range from 1:1 to 27:1. Spur gears in the units are hobbed and hardened. External bearing surfaces are brass to permit mounting in bushings. Units with an internal



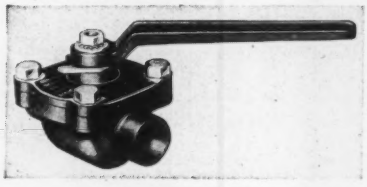
antibacklash feature are available. Two parallel gear trains spring-loaded against each other take up backlash. **Metron Instrument Co.,** 432 Lincoln St., Denver 3, Colo.

—Circle ITEM 61

Ball Valve

can be modified without removal from line

Direction of shut-off, change of seat material and cleaning can be performed on this top entry round flow ball valve without removing



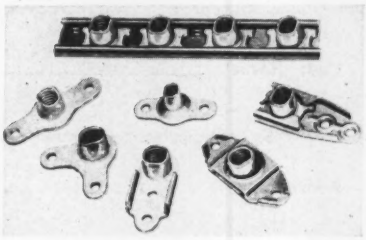
it from the line. Removal of the body cap permits reversing the cage assembly when direction of flow is changed. Seat material can be Buna-N, neoprene, Kel-F, Teflon, or nylon. Stem design permits placement of handle in any of eight positions. Valve is rated at 300 psi on water, oil and gas and 400 psi on LP gas. Made of bronze, it also can handle media such as oxygen and hazardous liquids. Valves are available with either sweat or screw ends, in ½, ¾ and 1-in. sizes. **Rockwood Sprinkler Co.,** 38 Harlow St., Worcester 5, Mass.

—Circle ITEM 62

Lightweight Locknuts

made of stainless steel, usable at 800 F

Lightweight stainless steel anchor and gang channel locknuts are nonmagnetic and will withstand temperatures up to 800 F. Configurations in this 70LHA line in-

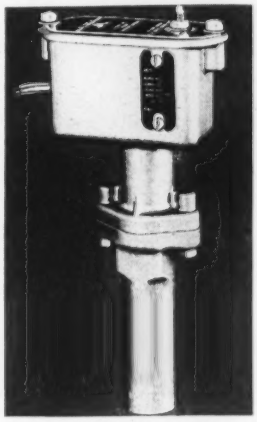


clude one and two-lug anchor or plate nut shapes. One floating nut body in the series has 0.030-in. minimum radial float, while another design offers multiple floating nuts installed in stainless channel strip. All designs are intended for blind mounting where nut is "fixed" to basic structure. Thread sizes available in the anchor line are 6-32, 8-32, 10-32 and ¼-28. The three largest sizes are also available as gang channel nuts. **Elastic Stop Nut Corp. of America,** 2330 Vauxhall Rd., Union, N. J.

—Circle ITEM 63

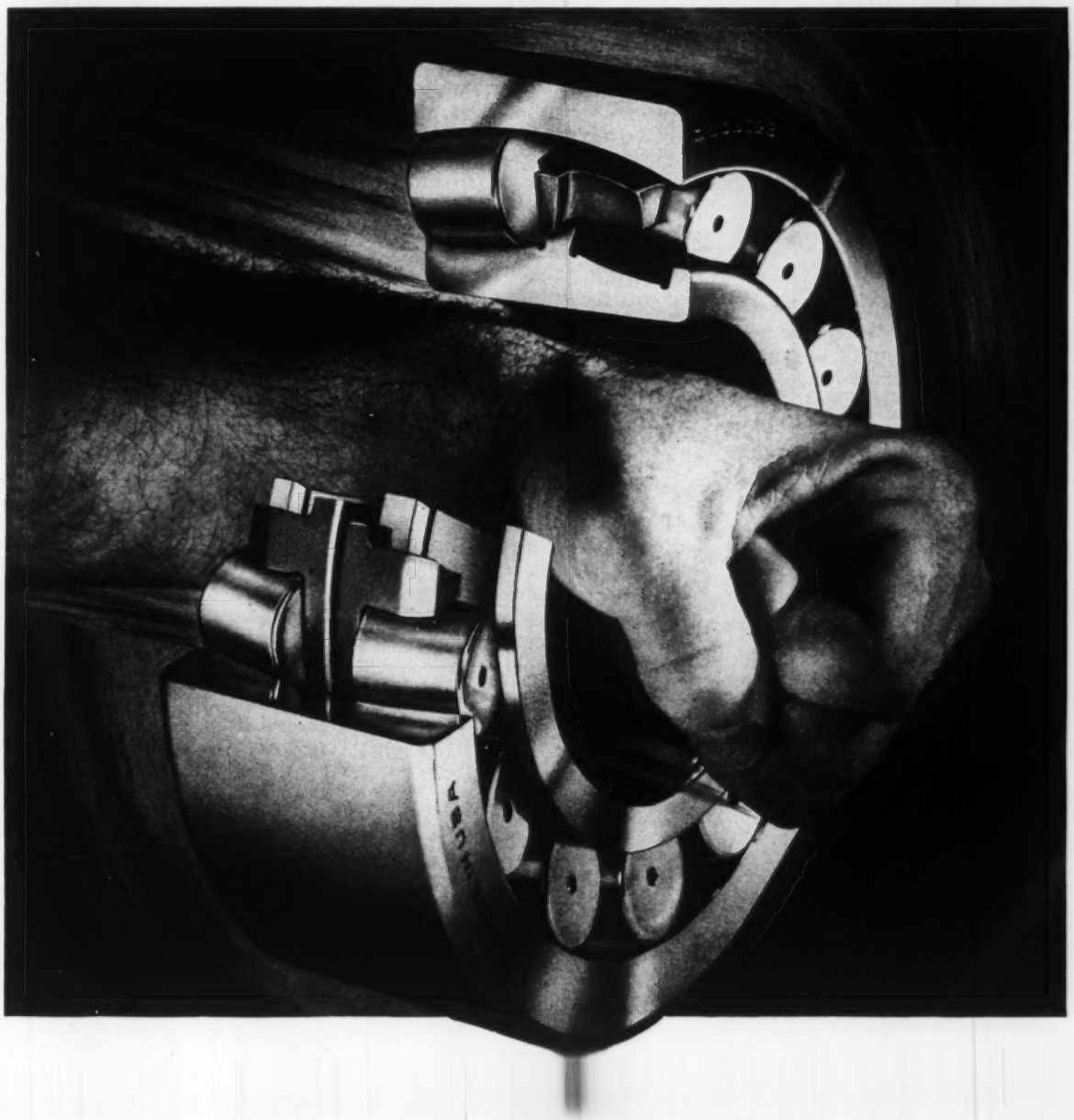
Pressure Switch

can be set without gages



Calibrated plate on model C9612 pressure switch permits setting it before or after installation on a pressure line. A tamperproof indicator inside the switch is visible through a window in the plate. Desired pressure is set by means of an external adjustment screw which can be locked in place. The switch senses any system pressure over an adjustable range of 15 to 3000 psi; the particular range can be covered by one of four classes of switch. Fixed actuation value varies from 10 to 250 psi, depending on switch setting. Piston type

TORRINGTON *SPHERICAL ROLLER* BEARINGS



This bearing can take thrust, too!

Design is the secret. TORRINGTON Spherical Roller Bearings are made with an integral center flange on the inner race. This assures *positive radial stability and accurate positioning of rollers* wherever high radial load and heavy thrust are encountered under conditions of misalignment.

From crushers to cranes, power shovels to pulverizers, you get long, maintenance-free operation, better performance in your equipment, more value from your bearing dollar when you specify these rugged dependable bearings.

Prove to yourself that TORRINGTON design does make a difference. Next time specify TORRINGTON Spherical Roller Bearings. They're available with either straight or tapered bore, for shaft or adapter mounting.

THE TORRINGTON COMPANY

South Bend 21, Ind. • Torrington, Conn.

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Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

—ITEM 197—

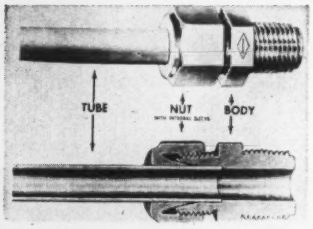
sensing element is not sensitive to jarring or vibration. Mounting bracket can be rotated to any position on a full circle or moved up and down on the neck of the switch. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

—Circle ITEM 64

Nylon Tube Fittings

for use with either plastic or metal tubing

Nylo-Seal tube fittings, molded from Du Pont Zytel can be used with stainless steel, aluminum, steel, copper, nylon and polyethylene tubing. The fittings are not affected by most acids, alkalis, petroleum oils or greases, and they withstand temperatures from −70 to 250 F. Recommended working pressures range from 150 to 500 psi, depending on temperature. Fittings have high impact strength, and joints made with them are vibration resistant. Fitting is composed of a body and nut with an integral sleeve. Flaring of the tube is not required for installation. Available sizes range from ¼ to ½-in. OD in unions, bulkheads, half unions, elbows and tees. Standard color is royal blue, but white fittings are available for use with foodstuffs. **Imperial Brass Mfg. Co.,** 1200 W. Harrison St., Chicago 7, Ill.

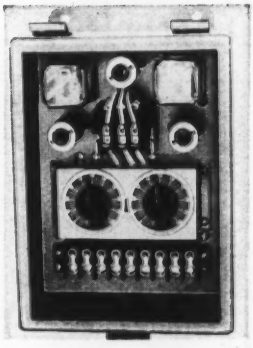


—Circle ITEM 65

Electronic Timer

has contacts rated at 20 amp

Independently adjustable on and off time ranges are incorporated in the model T 3 electronic timer, designed for life test equipment, proportioning controls and process or machine applications. Load contacts are double-pole, double-throw type and are rated at 20 amp, 115 v ac, noninductive load. The circuit employs cold cathode tubes which require no warm-up before use. Accuracy is ±1 per cent, independent of line voltage fluctuations from 105 to 125 v. Standard ranges are 0.3 to 25 and 0.5 to 50 seconds per section. Open style or NEMA XII construction is available. **Ferrara Inc.,** 8106 W. Nine Mile Rd., Oak Park 37, Mich.

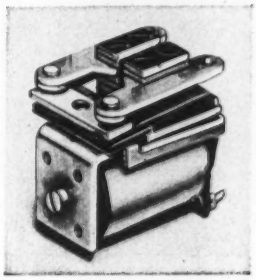


—Circle ITEM 66

Miniature Relay

in ratings up to 150 v dc

Switching of noninductive loads up to 20 amp can be performed by the class 11D miniature relay. It measures 1⅝ x 15/16 x 1 7/16 in. and has single-pole, single-throw, normally open, double-break contacts. Minimum coil operating power is ½-w. It is available for dc operation up to 150 v. **Magnecraft Electric Co.,** 3352 W. Grand Ave., Chicago 51, Ill.



—Circle ITEM 67

Air and Hydraulic Valves

have flat, compact bodies

Bodies of two, three and four-way, lever-operated air and hydraulic valves in CRV series are rectangular to provide flat surfaces on all sides for easy and compact mounting. Valve bodies are ¾-in. thick, 1½ in. wide, 3 13/16 in. long in

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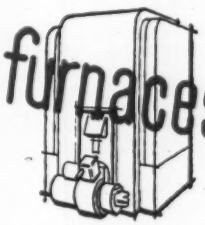
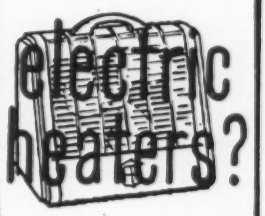
Want to eliminate noise or vibration in:

LORD couplings transmit torque evenly. Tub mountings dampen vibration and compensate for irregular loading or misalignment.



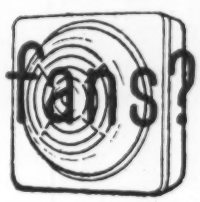
Furnaces operate quietly with fan hubs, blower mountings and base mountings by LORD.



Heater fans give hushed operation and are less distracting when equipped with LORD bonded-rubber fan hubs.

LORD mountings maintain alignment, eliminate vertical "bounce" and transmit even pressure to sanding plate.

Bonded-rubber fan hubs, pillow-block bearings, idler and drive wheels for smooth, noiseless performance.



Blade vibration and misalignment eliminated with LORD bonded-rubber fan hubs.

LORD mountings assure accurate seating of drive motor and absorb blade shock for smoother operation.

Bonded-rubber idler wheels eliminate turntable "rumble" — maintain the highest performance standards.

Motors and/or compressors mounted by LORD and fans equipped with bonded-rubber hubs team up to give cushioned, silent operation.

LORD couplings and mountings absorb cutter shock, assure positive positioning and deliver impulse-free power.

Compressor motor vibration and noise isolated with bonded-rubber motor mountings.

LORD idler and drive wheels prevent "wow" — assure "high-fidelity" output.

Noise and vibration can seriously affect the market preference for your product. Modern household appliances have greater sales appeal when equipped with these LORD "silent salesmen".

Find out how LORD bonded-rubber products can improve the performance of your product. LORD has over 30 years of experience in furnishing the best in vibration control and shock resistance to some of industry's most successful appliances. LORD Field Engineers are located in major industrial centers. Call, or write to the LORD office nearest you!

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—ITEM 199—

design data

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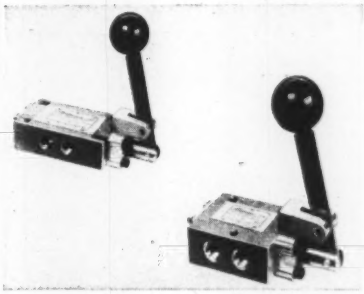


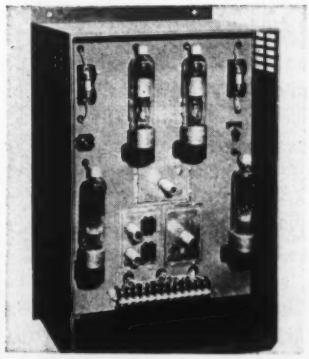
the three-way model and 4⅝ in. long in the four-way type. A single sliding spool is employed, and standard O-ring seals are used throughout. Body is aluminum, with a brass spool. Valves can be used at pressures to 200 psi. In addition to the hand lever type illustrated, they are available in palm button, foot lever, roller, cam or pilot-operated types. **Modernair Corp.,** 400 Preda St., San Leandro, Calif.

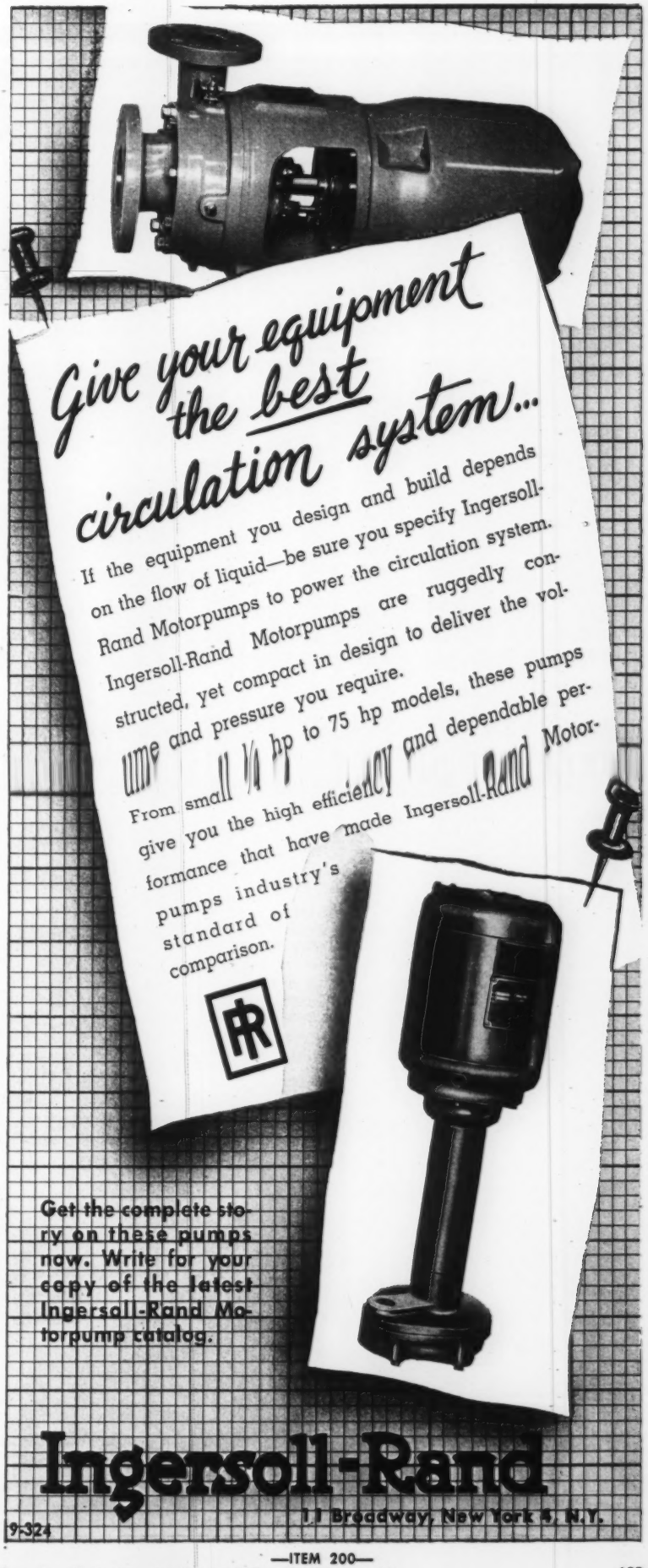
—Circle ITEM 68

Adjustable-Speed Drive

with speed range of 100:1

Machines requiring continuous speed adjustment up to 100:1 ratio can be driven by the VS-100 adjustable-speed drive. It is highly stable over the entire speed range. These ¼ to 4 hp drives are packaged with electronic control panels for mounting and integrating with other machine controls. Sealpak construction is employed, whereby all small electronic components are grouped, wired and sealed in plastic for protection from harmful atmospheres, vibration and shock. Drive can be modified to provide close speed regulation by tachometer feedback. It requires standard single - phase

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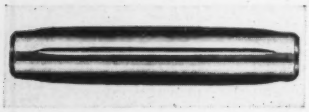
power. **Reliance Electric & Engineering Co.**, 1088 Ivanhoe Rd., Cleveland 10, O.

—Circle ITEM 69

Self-Locking Pin

can be hopper-fed

Designed for hopper feeding, type U self-locking pin is made with a pilot on each end to facilitate insertion and accurate starting of either end. Full-length grooves provide locking along the length of



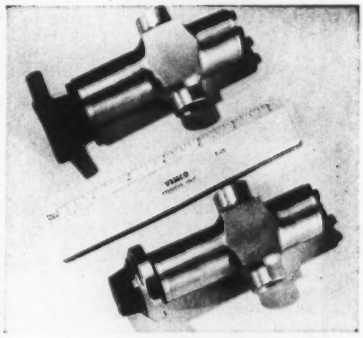
the pin. Parallel and equally spaced, the grooves are impressed on the shank of the pin, displacing a specific amount of metal on each side of the cut to form a raised flute. Driving the pin into a hole of the same nominal diameter as the shank compresses the flutes against the hole wall, creating a high radial holding force and providing resistance to shock and vibration. Pins are available in a wide range of sizes and materials. Applications include keying sprockets, gears, knobs, handles, levers and wheels to shafts. **Driv-Lok Pin Co.**, Sycamore, Ill.

—Circle ITEM 70

Metering Valves

have wide range of flow

Designed for metering or control service over a wide range of flow in high-pressure hydraulic systems, these valves can operate with small flow variation. A valve with $\frac{3}{8}$-in. tubing ports will control volume ranging from drops per minute to 25 gpm at 3000 psi pressure drop across the valve. Range, or ratio of maximum to minimum controllable flow, can be provided up to 100,000:1. Standard operating pressure limit is 3000 psi. The valves are hydraulically balanced and require low turning torque. A fine stem screw is provided for making fine adjustments. Bodies and internal members of the valve can be furnished in combinations of aluminum, bronze, stainless steel, and alloy or carbon steels. A multiple-turn



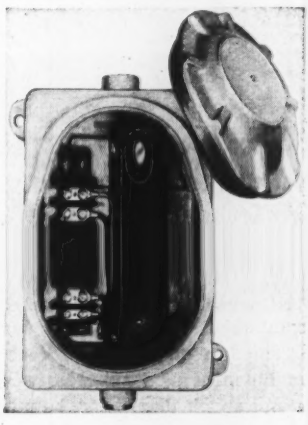
indicating dial handle can be included to permit rapid setting of the valve to a predetermined position. A motorized model, for either ac or dc, is available for remote positioning operation or for automatic control. **United Hydraulics Inc.**, 110 Terrel Ct., Dayton 7, O.

—Circle ITEM 71

Vibration Monitor

actuates warning signal or shuts down machine

Explosionproof vibration monitor detects mechanical malfunctions such as failing bearings or unbalance in such equipment as gasoline engines, pump motors, large fans and blowers. It actuates a warning or causes a shutdown when machine does not operate properly. The monitor can be provided with either a single-pole, double-throw or a double-pole, single-throw, normally open switch. An adjustment provides for a wide range of normal vibration levels. Electrical rating is 5 amp at 115 or 230 v ac resistive or inductive. The aluminum explosionproof housing is designed for Class I, Group D, Class II, Groups E, F and G and Class III locations. A weather-



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—ITEM 201—

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QUICK INSTALLATION. Bushing and sprocket assembly slips easily into position on shaft. Setscrews draw sprocket onto taper bushing, causing bushing to clamp tightly on shaft — equivalent to a shrink fit.

NO REBORING DELAYS. Bushings are stocked in bore increments of 1/16 in. for shaft sizes from ½ to 4-in. diameters. Sprockets mount with the tightness of a shrink fit.

BROAD RANGE OF SIZES. Taper Lock Sprockets and matching Precision Steel Roller Chain are stocked in 8 pitch sizes, ½ to 2 in. — an ideal combination from one source.

NEW BOOK 2649 contains complete specifications. Link-Belt Roller Chain Taper Lock Sprockets are usually made of steel. Where size and weight are considerations, spoked cast iron sprockets are furnished.

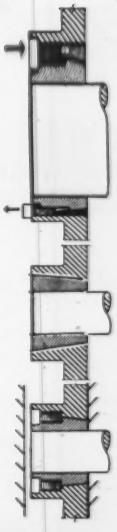
For your copy or more information, call your Link-Belt Office.

for the machine:

REMOVAL is easily and quickly accomplished by using setscrew as jack screw in hole provided, which releases sprocket assembly from shaft with a few quick turns.

FULL BEARING, POSITIVE GRIP. Full length of bushing supports sprocket on shaft. Tapered construction with uniform compression provides tightest, safest grip available.

NEAT APPEARANCE, SAFE, COMPACT. Flush mounting requires minimum shaft space, and bushing requires no more room than sprocket hub. No projecting bolts or flanges.



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made from selected mineral tanned leather—thoroughly wax impregnated . . . for pressures to 100,000 psi.

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accurately molded from select mineral tanned leather—wax impregnated, low friction . . . for pressures as high as 100,000 psi.

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Ready to give you
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—ITEM 203—

For More Information Circle Item Number on Yellow Card—page 19

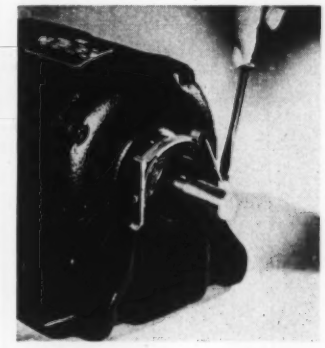
proof housing with external reset operator and locking means is also available. **Beta Corp.**, Forest Ave. at Ridge Rd., Richmond 26, Va.

—Circle ITEM 72

Clip Type Fastener

for mounting motors

Speed Clip for securing fractional-horsepower electric motors to



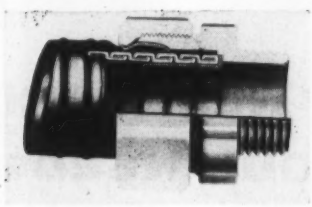
mounting brackets is attached quickly. Adaptable to any standard motor rated up to ¾-hp, the clip provides a firm attachment under severe vibrations and starting torques. Assembly is accomplished by clipping one end of the fastener over a notch on the motor mounting bracket and snapping the other end down over a notch on the opposite side of the bracket. Two clips are used for each mounting. **Tinnerman Products Inc.**, P. O. 6688, Cleveland, 0.

—Circle ITEM 73

Flexible Conduit Fitting

is positively grounded

Flexible liquid-tight conduit can be connected quickly, without disassembly, with the Liquid-Tite connector. Installation is accom-



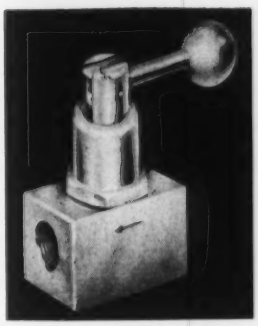
plished by loosening the nut, inserting the conduit, and tightening. Positive grounding is assured by the design of the brass grounding insert, which has convolutions to match those of the conduit. Inserting the conduit into the fitting produces an audible click, indicating proper contact. Tightening the nut reduces the diameter of the conduit to provide contact with the grounding insert. Sealing is achieved by tightening a brass sealing ring until it is compressed and coined into the body and nut to provide a solid mass. The connector is now available in a complete range of sizes for either straight, 45, or 90-deg connection. **Electrical Fittings Corp.**, 37-50 57th St., Woodside 77, N. Y.

—Circle ITEM 74

Shut-Off Valves

have quick-acting toggle levers

Circle Seal 900 series manual shut-off valves employ a quick-acting toggle lever for immediate and absolute shut-off. Sealing is provided by a resilient O-ring, which is protected from the fluid stream by a floating sleeve arrangement. Although the valve opens and closes quickly, the stem crosses a throttling seat, which assures gradual starting or stopping of the flow



and prevents shock or water-hammer in the system. Detent locks valve in open or closed position. Rated at 0 to 3000 psi, the valves can be used in either hydraulic or pneumatic service. They can be panel mounted. **James-Pond-Clark**, 2181 E. Foothill Blvd., Pasadena 8, Calif.

—Circle ITEM 75

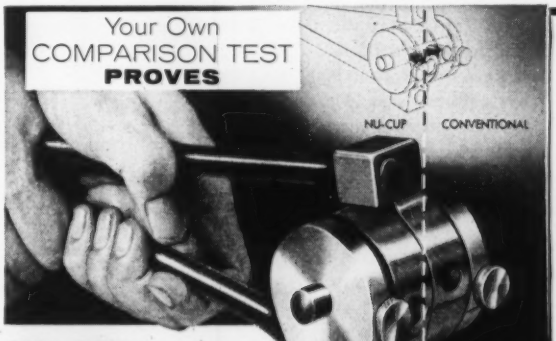
Adjustable-Speed Motor

provides stepless control from zero to 2400 rpm

Self-contained ac induction motor employs the Schrage principle for stepless control from zero to 2400 rpm, with torque approximately

(*Continued on Page* 130)

Your Own COMPARISON TEST PROVES



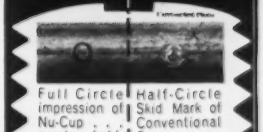
NU-CUP SET SCREWS have greater holding power

Without cost or obligation, send for "Nutcracker" Testing Tongs to compare Nu-Cups, yourself, with set screws you now use. See with your own eyes conclusive proof of Nu-Cup's greater holding power. See how Nu-Cups end slippage, screw heads cracking, and other set screw troubles.

Nu-Cup now available with Hex Socket Head . . . as well as slotted or slabbed head.

No need to write a letter. Simply fill out and mail the coupon at the right, to get your "Nut-Cracker" Nu-Cup Tester. Send for it now.

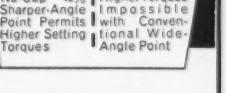
the shaft tells the story!



Full Circle impression of Nu-Cup . . . greater holding power.

Half-Circle Skid Mark of Conventional Screws . . . permits slippage.

And This Is The Reason:



Nu-Cup 42° Sharper-Angle Point Permits Higher Setting Torques

Higher Torques Impossible with Conventional Wide-Angle Point

Set Screw & Mfg. Co.

28 Main St., Bartlett, Ill. (Chicago suburb)

1137PDM

We specialize in Solving Puzzling Set Screw Problems

Use This Convenient Coupon

SET SCREW & MFG. CO., 28 Main Street, Bartlett, Illinois

I would like to receive without cost or obligation, Nu-Cup "Nut-Cracker," to make my own comparison test of holding power of Set Screws.

INDIV. NAME.....

COMPANY.....

ADDRESS.....

.....CITY.....ZONE....STATE.....

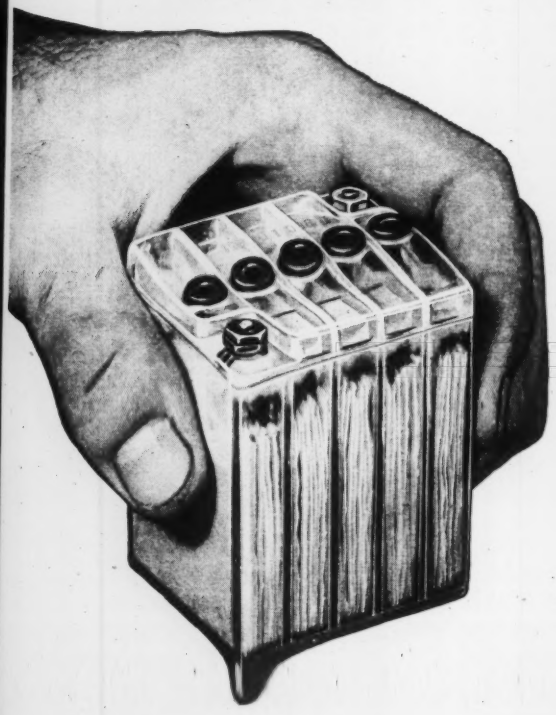
—ITEM 204—

Next Page—ITEM 205

BAKELITE

C-11

PLASTICS



Case and cover molded by **Vichek Tool Co.,** Cleveland 4, Ohio, for battery made by American Machine & Foundry Co., Micro-Pak Power Div., Colorado Springs, Colo.

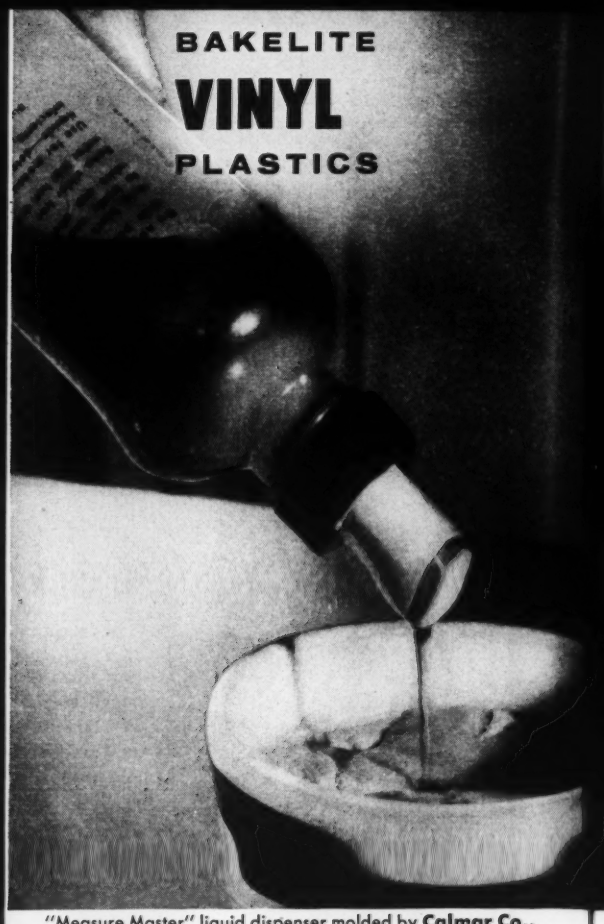
Boasting 100 per cent reliability, this compact silver-zinc battery is used in airborne ordnance, guided missiles, and jet aircraft starting systems. It strikingly demonstrates the serviceability of BAKELITE Brand C-11 Plastic, the material from which its case and cover are molded.

BAKELITE C-11 Plastic, an acrylonitrile-styrene copolymer, is chemically inert to the battery's potassium hydroxide. C-11 has the toughness, rigidity, and tensile strength to withstand vibration and mechanical and thermal shock; outside dimensional tolerances are not distorted by internal and external pressures. C-11's heat distortion point is above the 170-180 deg. F. reached by the battery's high current rate discharge. Case and cover are joined with compatible cement. Excellent transparency permits inspection of the battery during assembly and operation.

BAKELITE

VINYL

PLASTICS



"Measure Master" liquid dispenser molded by **Calmar Co.,** Los Angeles 1, Cal. for Isle of View Co., Los Angeles 43, Cal.

One spoonful at a tilt is automatically measured out by this dripless dispenser. No waste of contents, no extra hand motions. In addition, it's reusable on bottles with the same neck size.

Made from BAKELITE Brand Vinyl Plastics, the dispenser is practical for use with cosmetics, soap, detergents, antiseptics, medicines, and flavoring syrups. The smooth surface resists wear and abrasion... keeps its attractive appearance. Molded parts are VG-3620 ivory. The gasket is cut from an extruded strip of VG-1914 clear. When not in use, the dispenser is capped by an air-tight closure also molded of BAKELITE Vinyl Plastic.

BAKELITE

TRADE-MARK

GREATEST VARIETY, LARGEST RESOURCES FOR PLASTICS KEYED TO YOUR NEEDS

It's most economical, least time-consuming to get a *complete service package* from one dependable source. That's why it makes sense to do business with Bakelite Company.

Bakelite Company offers the most comprehensive package of all, both in terms of product and service. A wide variety of plastics is always available to meet your requirements. The experience and knowledge of one of the largest research and development teams in the industry are yours to draw on whenever you need them. Uniformity of materials, strategically located plants and warehouses, and prompt delivery and service complete the package. Put it to work for you. Write Dept. LK-103.

BAKELITE

POLYETHYLENE

PLASTICS

"Pro-Caps" for high-pressure grease fittings manufactured by **YBF Corp.**, Washington, D. C.

These caps molded of BAKELITE Brand Polyethylene protect grease fittings. Tough and resilient, they guard against burrs and scratches, and fit tightly enough to keep dirt, grit, and water out of shims and bearings.

The caps have withstood laboratory and field tests on combat vehicles, gun mounts, amphibious tractors... over a temperature range from minus 40 to plus 200 deg. F., on dirt roads, through water. Greases, lubricating oils, paints, transmission fluids have so little effect that the caps can be reused indefinitely. In addition to providing durability, BAKELITE Polyethylene permitted the use of colors and kept the precise dimensions needed for a firm fit.

BAKELITE

PHENOLIC

PLASTICS

X-ray film unit molded by **Sulak Manufacturing Co.**, Seattle, Wash., for Ind-X System, Inc., Seattle, Wash.

This portable unit for loading, exposing and processing industrial X-ray films in daylight consists of three sections molded of BAKELITE Brand Phenolic BMG-5000 Black. It's designed and built for hard use . . . indoors or out . . . in the field or factory.

But in selecting the molding material, the makers had much more to consider than mechanical strength alone. BMG-5000 is a general-purpose material that withstands repeated exposure to corrosive photographic solutions, both acid and alkaline. It keeps its dimensional stability despite extremes in temperature found in the field. It has good moldability—close tolerances, freedom from warpage and blisters.

If your product needs this combination of properties, look into this superior general-purpose Phenolic.

BAKELITE
BRAND
PLASTICS

PHENOLICS • STYRENES • IMPACT STYRENES
POLYETHYLENES • VINYLS • POLYESTERS
EPOXIES

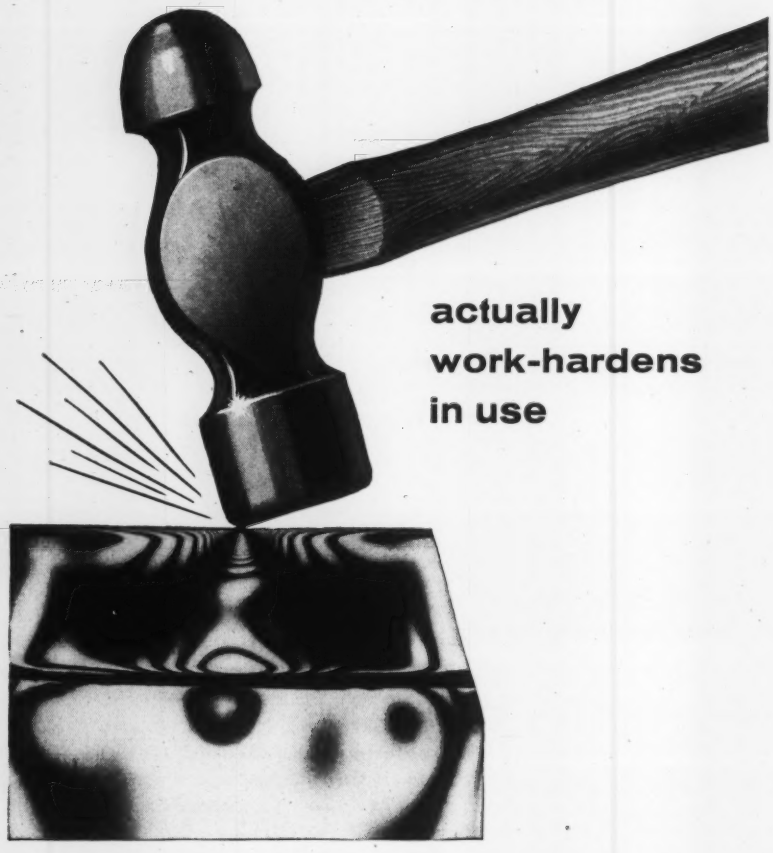
BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N.Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

AMSCO®
MANGANESE STEEL

absorbs impact energy...



actually work-hardens in use

If you require steel with high strength, good ductility and excellent resistance to abrasion accompanied by impact... use Amsco manganese steel, the toughest steel known.

Amsco manganese steel actually absorbs impact energy which work-hardens the metal's surface up to a maximum of 550 BHN, while below the surface (as shown by the photoelastic stress pattern in the illustration) manganese steel maintains its ductility. The more it's used, the harder and more polished the surface becomes. This self-polishing characteristic minimizes wear and reduces the need for frequent lubrication.

For a complete discussion of its technical aspects and inherent design features, send for your *free* copy of the Amsco booklet, *Austenitic Manganese Steel.*

AMERICAN MANGANESE STEEL DIVISION

AMERICAN Brake Shoe COMPANY

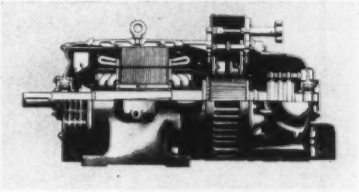
Chicago Heights, Ill.

—ITEM 206—

New Parts

(Continued from Page 127)

constant at all speeds. No external devices are employed to vary speed. Ratings range from ½ to 75 hp, for 220 or 440-v, 60-cycle, three-phase operation. Enclosures are



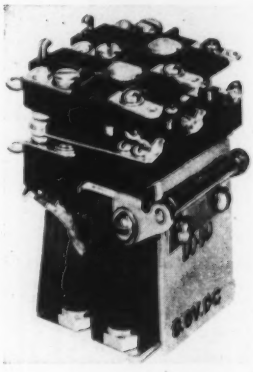
dripproof or pipe-ventilated. A large radial fan draws air in at the front, circulates it through the motor and expels it at the drive end of the motor. Speed is varied by turning a control knob or by means of a servo unit. Distributed by **ACEC Electric Corp.**, 40 E. 49th St., New York 17, N. Y.

—Circle ITEM 76

AC or DC Relay

withstands severe shock and vibration

Usable in applications subject to severe shock and vibration, model DO general purpose relay has a maximum contact combination of four-pole, double-throw. Contact



and terminal insulation is of molded phenolic material. Design of the molded parts around the moving contact arms affords maximum protection against mechanical injury. Contact rating is 10 amp at 115 v ac or 32 v dc noninductive load. The relay is available in a wide range of operating voltages for either ac or dc. **Ohmite Mfg. Co.**, 3682 Howard St., Skokie, Ill.

—Circle ITEM 77

Here's the story...

ON Century 's NEW SMALLER, BETTER MOTORS 1 TO 30 H.P.

In this revealing book, Century shows how and why the *New Standard*, smaller motors actually outperform the larger, heavier Old Standard models.

These trim, compact "*New Standards*" give you weight savings up to 40% . . . plus space savings and easier installation. Dead weight and dead air space are eliminated. The "active materials," such as iron and copper, are designed to give greater efficiency than ever before. New synthetic insulating materials give greater dielectric strength and uniformity.

Century
SMALLER, YES... AND BETTER!
erformance ated
MOTORS
1 to 30 HORSEPOWER
How... you ask?
GREATLY IMPROVED MATERIALS... BETTER VENTILATION TO TRANSFER THE HEAT... ELIMINATION OF DEAD WEIGHT AND USELESS SPACE... IMPROVED DESIGN AND CONSTRUCTION.

SEND FOR YOUR *PERSONAL* COPY OF THIS VALUABLE DATA BOOK...!

Mail this coupon today!

To CENTURY ELECTRIC COMPANY
1806 Pine Street, St. Louis 3, Mo.

Please send New Bulletin 6-1P1 to:

Name.....*Title*.....

Company.....

Address.....

City.....*Zone*.....*State*.....

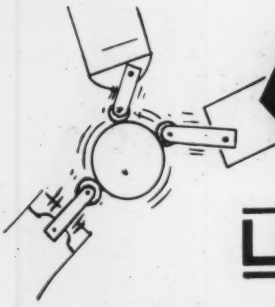
***Performance Rated*©**
MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

45

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

—ITEM 207—



INDEPENDENT TESTS BY LARGE MICHIGAN UNIVERSITY REPORT:

LOXSWITCH

LIMIT SWITCHES HAVE *Longest Mechanical Life!*

● Independent tests made by the Electrical Department of a large Michigan university on the three leading limit switches for a machine tool manufacturer, proved that Loxswitch has by far *the longest mechanical life!* In one test Loxswitch was still in good operating condition after 9,000,000 actuations, while Switch B failed after completing 1,500,000, and Switch C at less than 500,000 actuations*. Such tests time and again prove Loxswitch gives machine tool manufacturers and users far better equipment performance, less machine tool downtime, and reduced limit switch cost. Double contact pressure, 50% to 100% faster break, low impact and 70° safety overtravel help make it the finest switch on the market today!

*Our representatives will be glad to show you a copy of this report.

LOXSWITCH gives you . . . longest mechanical life; soundest electrical circuit; tightest enclosures

FEATURES	Series L100 LOXSWITCH	Heavy Duty Switch B	Heavy Duty Switch C
Electrical			
Contact Impact Mass—grams	2.45	11.03	7.83
Speed of 'Break'—in. per sec.	48	25	36
Typical 'Bounce'—milliseconds	4	16	4
Contact Pressure at trip point—oz.	8	4	4
Mechanical			
Operating Shaft Diameter	½"	½"	⅜"
Lever Roller Pin	Hard	Soft	Soft
Safety Overtravel	70°	30°	80°
Actuating Force—oz.			
To trip	125	220	185
for max. overtravel	135	435	230
for reverse travel	35	435	85
Number of Rotating Parts	4	6	9

All of the above Loxswitch features add up to far greater electrical and mechanical life—3 to 5 times greater under severe operating conditions.

FREE—12 pg. Catalog describes 7 models, 19 contact arrangements, 150 lever styles. Write for copy today to:

LOXSWITCH

HEAVY DUTY LIMIT SWITCHES

R. B. DENISON MFG. CO. 102 St. Clair Avenue, N. W., Cleveland 13, Ohio

Specializing Exclusively in the Manufacture of Limit Switches

—ITEM 208—

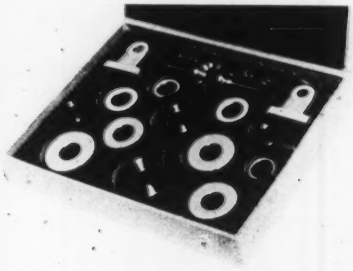
ENGINEERING DEPARTMENT

EQUIPMENT

Precision Differential Kits

with wide range of interchangeable end gears

Universal differential kits designated type V1, V4 and V7 include a wide range of interchangeable end gears having from 63 to 160 teeth in both aluminum and stainless steel. Shaft hangers, Barden ball bearings and set collars are



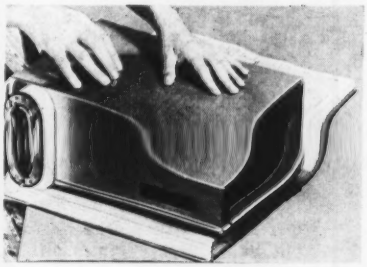
also included. All gears are cut to AGMA precision 1 tolerances and have 20-deg pressure angles. Units are available in ⅛, 3/16 and ¼-in. shaft sizes with 72, 64 and 48 pitch gears, respectively. **PIC Design Corp.,** 160 Atlantic Ave., Lynbrook, L. I., N. Y.

—Circle ITEM 78

Photocopier

contours copy paper to curvature of original

Portable Contoura-Constat transfer process photocopier makes black-on-white copies of printed, typed,



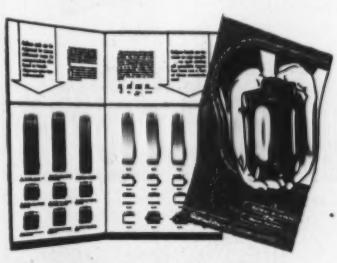
written or drawn material in about 30 seconds. Original can be printed on one or both sides and either

(*Continued on Page* 136)

YOUR No. 1 SOURCE FOR COMPLETE BELLOWS ASSEMBLIES AND DEVICES

FULTON SYLPHON BELLOWS HEADQUARTERS, U.S.A.

You gain three important advantages when you consult Fulton Sylphon, originators of the metal bellows—*1.* Over 50 years experience in bellows engineering is focused on your problem; *2.* Modern production facilities geared to good service; *3.* Cost saving opportunities through the design and production of complete bellows assemblies.



HERE'S HELPFUL INFORMATION
This 32 page catalog covers basic bellows engineering, conversion tables, metals available and other bellows data. Use the handy coupon for your free copy.

Mr. Controls®

Robertshaw-Fulton
CONTROLS COMPANY

FULTON SYLPHON DIVISION
Knoxville 1, Tennessee

( ) Please have a Bellows Engineer call me for an appointment.

( ) Send me Bellows Catalog # A1400.

Name_____ Title_____

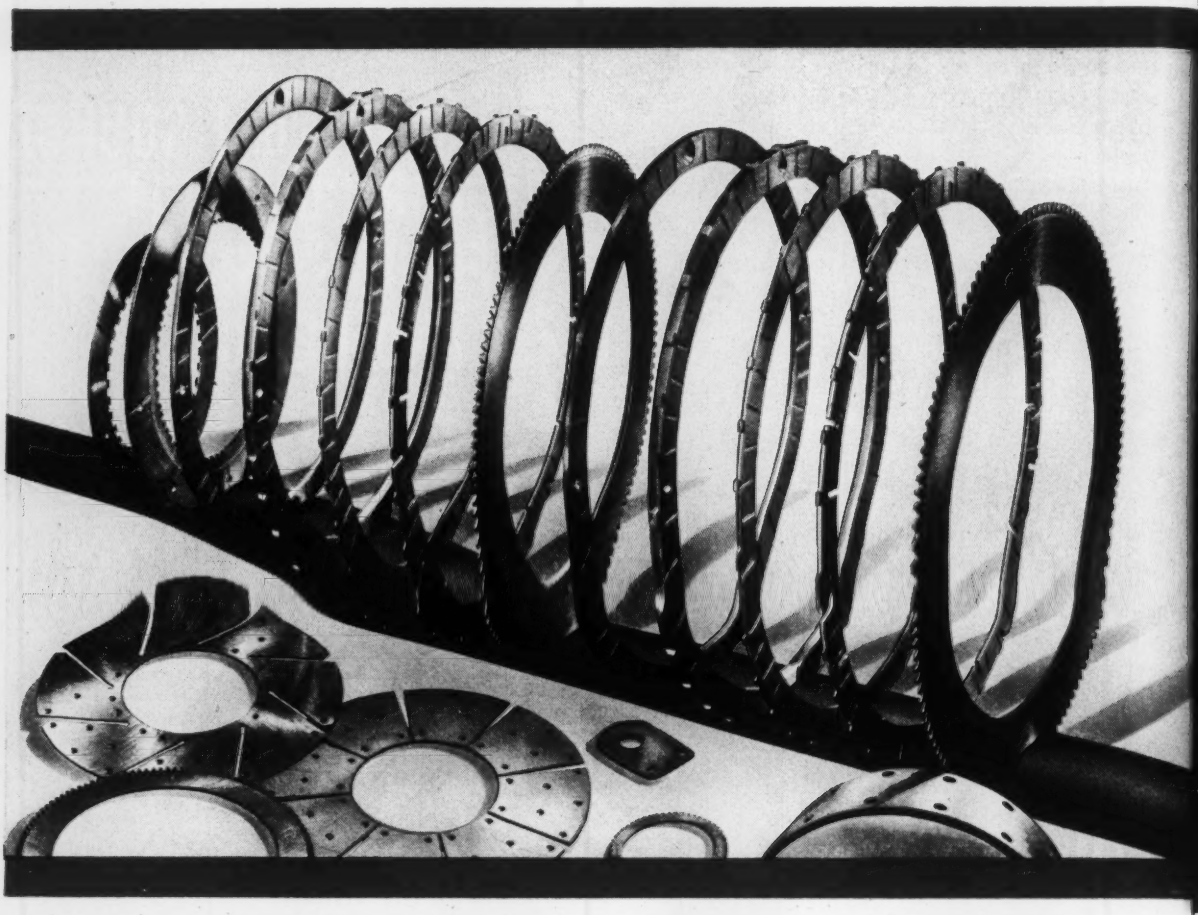
Company_____

Address_____

City_____ State_____

—ITEM 209—
For More Information Circle Item Number on Yellow Card—page 19

CALL ON R/M ENGINEERING SERVICE



R/M SINTERED METAL FOR HEAVY DUTY FRICTION JOBS

Wherever high heat, close tolerance, or rapid repetitive engagement is a factor in friction-material performance, Raybestos-Manhattan sintered metal friction parts may give you greater output and greater durability.

Speaking generally, sintered metals are most useful where K.E. absorption per square inch of friction material is very high. Under such conditions, R/M sintered metal friction parts will give better performance because of their high thermal conductivity and absence of a destructible bond.

Remember, however, that sintered metals are intended to *supplement* asbestos molded and woven lines—not *replace* them. That's why R/M, leader in both the asbestos and metal fields, is in an ideal position to help you. R/M works with *all* kinds of friction materials. So when you consult an R/M engineer you are sure of a completely unbiased recommendation as to which materials are best for your particular application.

If friction material performance could be improved in your applications, consult R/M now. All the depth and breadth of R/M experience in friction—the facilities of R/M's seven great plants with their research and testing laboratories—are as near as your telephone.

Write for your copy of R/M Bulletin No. 500.

It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METALS, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Fan Belts and Radiator Hose

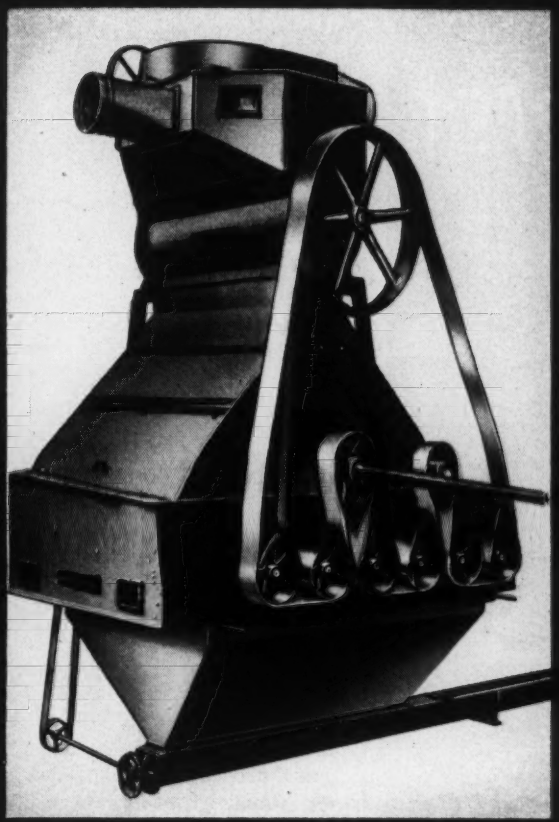
Mechanical Packings and Gaskets

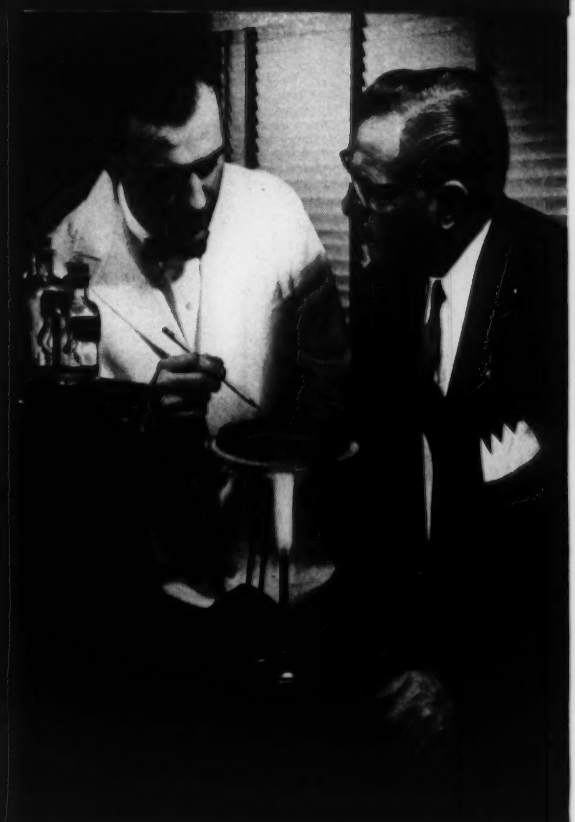
Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS





TRANSMISSION BELTS CONDOR WHIPCORD ENDLESS BELT

As an all-purpose belt for use on all types of endless drives, the Condor Whipcord Endless Belt offers exceptional advantages for tough drive designs—small pulleys, reverse bends, small take-up, short centers, high tension, heavy loads, and high speeds. It is made with strong endless-wound cord, is extremely flexible, and will not stretch or shrink on the drive . . . because it is virtually unaffected by atmospheric conditions. The "Extensible-Tip," an exclusive cover end splice design helps Condor Whipcord Belt outlast 3 to 10 ordinary belts on many drives. Let R/M specialists work with you if your machine design calls for transmission belts, Poly-V Drives, V-belts, conveyor belts, hose or molded rubber or Nylon parts.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

PACKINGS, GASKETS ASBESTOS TEXTILES and "TEFLON"* PRODUCTS

R/M packings do an outstanding job of lengthening equipment life and lowering maintenance costs. One reason is their superior lubrication. Locked in during manufacture, the lubricants are all through the product. Heat can not dissipate them. Pressure can not force them out. If you have a packing problem, call on R/M's specialized packing engineering service. R/M makes a complete line of mechanical packings—including Vee-Flex, Vee-Square, Universal Plastic, and "versi-pak."® It can also meet your requirements for asbestos textiles and "Teflon" products.

**Du Pont trade mark*

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION
Raybestos Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

—ITEM 210—
For More Information Circle Item Number on Yellow Card—page 19

Top QUALITY CONTROL calls for RECORDED EXACTNESS

Myriads of details go hand in hand with Quality Control. For one example, at the onset of production, a casting is "destroyed" by sectionalizing to determine dimensional accuracy. Irregularities can be corrected, molding methods acknowledged, and the general structure can be proved before subsequent costs are expended.

As illustrated above, the transparent "sectional template" visually approves interior members and voids, as well as outlines finish surface adequacy for the record.

Complete progress is recorded, and any time after inception —costs, revisions, equipment function, production details . . . and even difficulties encountered can be itemized with exactness.

It all adds up to *top quality control* service. This service can be *your* service. Write or call for complete information.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec.

Unitcast

QUALITY STEEL CASTINGS

—ITEM 211—
For More Information Circle Item Number on Yellow Card—page 19

Engineering Equipment

(Continued from Page 132)

flat or permanently mounted. An inflatable plastic cushion forces copy paper to conform to the curvature of book pages, preventing distortion. Powerful light output allows the use of paper which is not extremely light-sensitive. Unit can be used under normal office lighting conditions. A built-in timer assures accurate exposure. Two sizes are available. The larger model accommodates material up to 8½ x 14 in. **F. G. Ludwig Inc.,** Old Saybrook, Conn.

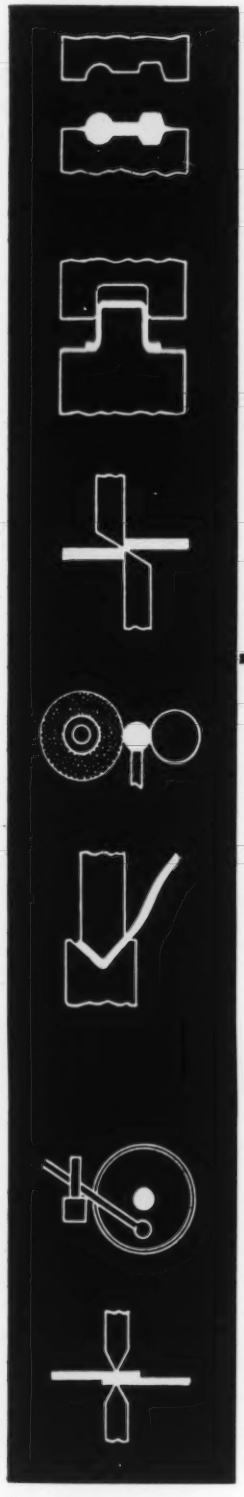
—Circle ITEM 79

Torque Source

also usable as calibrated dynamometer

Electric calibrated torque source tests and measures the torque characteristics of such devices as pallet mechanisms, small gear trains, servos, springs and clutches. A universal chuck on the front panel, driven by a three-phase motor, supplies the torque, which is shown directly in ounce-inches on a large meter. Shaft speed is indicated on another meter, and output jacks provide for external recording of both torque and speed. A table mounted parallel to the output shaft provides quick alignment of objects under test. Auxiliary mounting brackets are available. Usable as a torque source as well as a calibrated dynamometer, the unit has a range of 0.05 to 40 oz-in. with more than 5 per cent overall accuracy at shaft speeds from zero to 100 rpm. Other speed ranges are available. Cabinet has a recessed panel with illuminated work area. **Bulova Research and Development Laboratories Inc.,** Equipment Div., 62-10 Woodside Ave., Woodside 77, N. Y.

—Circle ITEM 80



A Design Guide to Production Characteristics of ENGINEERING METALS

A symposium of 15 articles on selection of metals for optimum production processing

A co-ordinated approach directed at one major problem in materials selection. As part of a continuing program on materials used in design, these articles deal with the more common engineering metals. Here is engineering help in matching a selected metal with its logical production methods.

These are the metals and processes covered:

WROUGHT CARBON AND ALLOY STEEL
- Drawing Properties
- Machinability
- Weldability
- Forging Characteristics
- Cold Heading Properties
- Hot Extrudability

WROUGHT STAINLESS STEEL

GRAY IRON

MALLEABLE IRON

CAST STEEL

CAST STAINLESS STEEL

BRASS, BRONZE AND COPPER

WROUGHT ALUMINUM ALLOYS

CAST ALUMINUM ALLOYS

MAGNESIUM ALLOYS

Order your copies today

MACHINE DESIGN
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Penton Building
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(Add 3% to orders for delivery in Ohio to cover state sales tax)

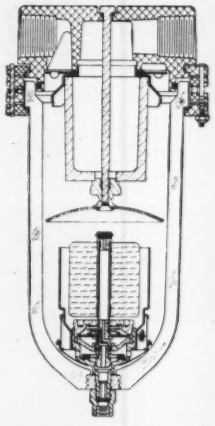
3 NEW NORGREN AIR LINE FILTERS

New Sizes of Automatic-Drain Filters

added to Norgren Line

Automatic-drain filters for use with ¾" and 1" air lines are now being manufactured by Norgren in addition to their present models for use with ¼", ⅜" and ½" air lines. Three filter elements are available —74, 64, and 25 microns.

Norgren Automatic-Drain Air Line Filters filter oil, corrosive moisture, abrasive pipe scale, rust and other solids from compressed air. A float controlled, pilot operated drain mechanism, operating under constant or fluctuating line pressures with or without air flow, automatically drains collected liquids. For trouble-free operation and reduced wear, the solids are prevented from entering the drain mechanism.



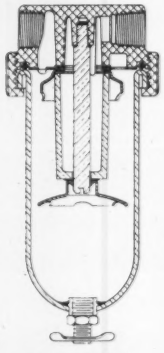
Models 11,200-6 and 11,200-8
¾", 1" Pipe Sizes

New Metal Bowl Filter

for higher temperatures and pressures

A new model replaceable metal bowl air line filter has been added to the Norgren line. The metal bowl allows the filter to be used at temperatures from —40° to 300° F and at pressures ranging up to 250 psi.

These filters are designed to create a strong centrifugal force that "wrings" a high percentage of moisture and oil from the air. A baffle traps liquids and solids in the Quiet Zone in the bottom of the bowl and prevents them from re-entering the air line. Three filter elements are available — 74, 64, and 25 microns.



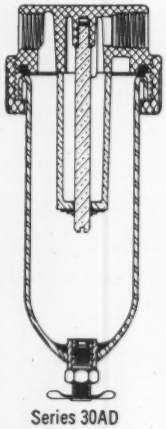
Series 12,200N
¼", ⅜" Pipe Sizes

New Replaceable Bowl Filter

a better low cost filter

Norgren is now manufacturing a new, low cost filter for applications where the removal of solids from the air is of primary importance. The replaceable bowl can easily be removed for cleaning or it can quickly be replaced if accidently damaged in use.

The filter part of the unit, a reinforced 200 mesh Monel wire screen, or sintered metal filters of 64 and 25 microns, is easily removed for cleaning without removing the entire unit from the air line. There are no moving parts to wear out and the filter functions with a minimum of pressure drop.



Series 30AD
¼", ⅜" Pipe Sizes

There is a Norgren Air Line Filter for every air line need.

For complete information about Norgren Air Line Filters, phone your nearby Norgren Representative listed in your telephone directory . . . or **WRITE FOR NEW NO. 700 CATALOG.**

C. A. Norgren Co.
3442 So. Elati, Englewood, Colo.
PRESSURE REGULATORS • AIR LINE FILTERS LUBRICATORS • AIR CONTROL VALVES

—ITEM 212—

THE ENGINEER'S Library

Recent Books

Basic Lubrication Practice. *By Allen F. Brewer; 286 pages, 6 by 9 inches, clothbound; published by Reinhold Publishing Corp., New York; available from* MACHINE DESIGN, *$6.75 postpaid.*

Directed to lubrication and maintenance engineers, this text provides information needed to select and compare lubricants for industrial and power plant machinery.

Twenty-four chapters cover physical tests of lubricants, types of bearings and bearing materials, the lubrication of conventional machine elements, steam and internal combustion-engine lubrication, the electric motor, and lubricants for pneumatic, refrigeration and hydraulic equipment. References follow the principal chapters.

Association Publications

Proceedings of the American Society for Testing Materials, Volume 54, 1954. *1412 pages, 5¾ by 9 inches, clothbound; published by and available from the society, 1916 Race St., Philadelphia 3, $12.00 per copy.*

These proceedings contain the summary of the annual ASTM meeting in June 1954 and other society papers for the same year. The latter include 68 technical committee reports, 37 technical papers and discussions, all symposiums originally published separately, and papers first printed in the society's Bulletins. Contents of the volume pertain to research and testing of a wide variety of materials.

♦

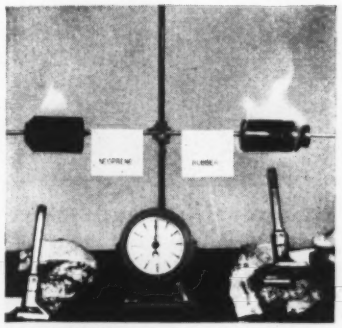
Professional Engineers' Income and Salary Survey. *43 pages, 6 by 9 inches, paperbound; available from National Society of Professional En-*

DU PONT ELASTOMERS

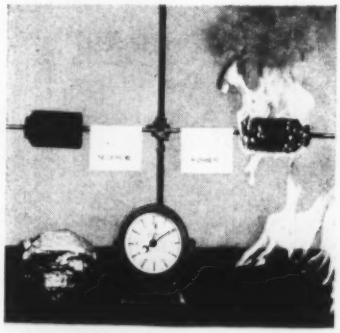
NEOPRENE – HYPALON

in Design

NEOPRENE ROLLERS PASS FLAME TEST!



PRINTING ROLLERS of neoprene (left) and natural rubber (right) are exposed to the flame of Bunsen burners until they ignite.



IN FIVE SECONDS after burners are removed, flame on neoprene roller is out. After 69 seconds, drippings from flaming rubber roller have ignited newspaper.

This test convinced management of the New York *Daily News* that neoprene printing rollers offer an extra measure of safety over natural rubber. Today, they flame test all rollers before they buy—and neoprene rollers are the only rollers that meet the test.

Neoprene's resistance to flame may well be useful to you as an added safety factor in your product designs. And neoprene offers resistance to abrasion, oil, heat, and chemicals as well. For all general-purpose applications, you can count on neoprene for long-term service. Clip coupon for further information.

Resilient gaskets of HYPALON® unaffected by 2% ozone

Re-usable after 2 years in ozone generators

For two years now Emery Industries has been using HYPALON synthetic rubber gaskets to seal its ozone generators. The company's ozone-producing installation is the largest in the country. Its operations supervisor, Robert Peters, made this report on HYPALON. "No failures with HYPALON gaskets in two years, even though they've been exposed to 2% ozone."

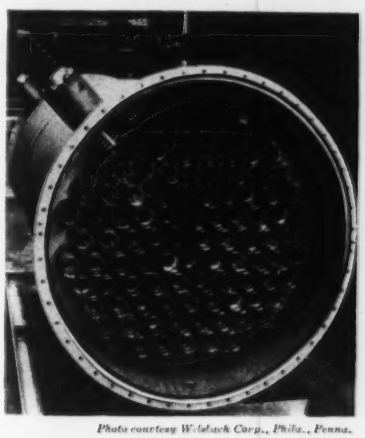


Photo courtesy Welsbach Corp., Phila., Penna.

HYPALON gasket on ozone generator showed no sign of deterioration after two years of service.

Design of the generator

The generator used by Emery Industries consists of a steel shell packed with a series of glass tubes individually encased in an electrically charged metal enclosure. A conductor carries an opposing charge through the glass tubes to make, in effect, a large electrical condenser. Dry oxygen is passed along the length of the glass tubes and converted to ozone. The generators are closed at each end by a dished head sealed with HYPALON gaskets.

HYPALON replaces plastic

Formerly, plastic gaskets were used in the generator. While unaffected by ozone, plastic gaskets had to be replaced after each maintenance checkup because they were too rigid for re-use. HYPALON gaskets, even after two years of service, retain their resilience and are still re-usable. Says the generator manufacturer, Welsbach Corporation, in Philadelphia: "We use HYPALON gaskets because they have the best over-all combination of properties of any we've found—including ozone inertness, resilience and cost."

Designing with HYPALON

HYPALON means extra-long life at lower operating costs for resilient products subject to severe service conditions. It can operate at temperatures from 250°F. to 350°F. It is particularly resistant to most oxidizing chemicals. And HYPALON resists weather and sunlight attack and can be compounded in an unlimited range of stable colors. For more information about HYPALON, clip and mail the coupon below.

DU PONT

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HYPALON *is a registered trademark of E.I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Please send further information and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-1
Wilmington 98, Delaware

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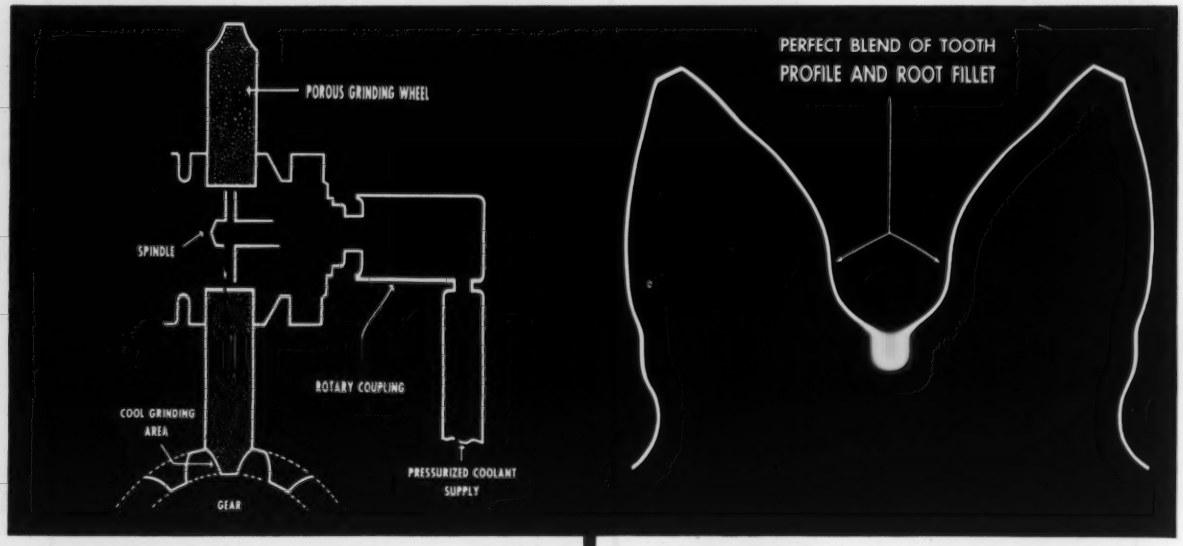
These Unique Features

MAKE PRECISION GRINDING OF GEARS MORE PROFITABLE THAN EVER BEFORE



NON-TEMPERED, CASE-HARDENED GEARS

A controlled flow of coolant through the grinding wheel is supplied to the area between the grinding wheel and the gear tooth. This feature, coupled with the automatic down feed, virtually eliminates surface tempering and grinding checks.

PERFECT BLENDING OF FILLET AND PROFILE

Single or double diamond trimmers are used to assure a perfect blend between the tooth profile and the root fillet. This eliminates stress risers at the critical section of the tooth.

Pratt & Whitney's J-57 Turbojet: The most powerful aircraft production engine in the world is rated in the 10,000-pound thrust class.

19 Gear Grind Machines are used in the production of the Pratt & Whitney J-57

At Pratt & Whitney Aircraft, where finest quality gears and high production are essential to the manufacture of the J-57 Turbojet, 19 new automatic Gear Grind Machines are in daily use. Here is what Pratt & Whitney has to say:

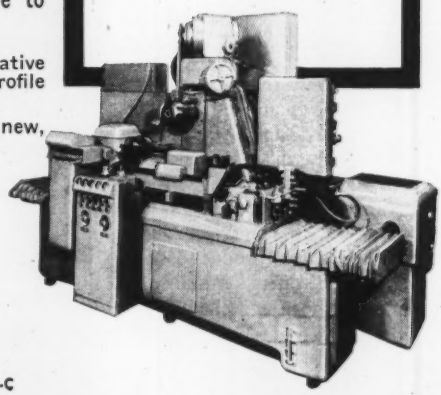
"The new Gear Grind Machines presently used in the aircraft engine division are the first major development in this type of machine since their use at Pratt & Whitney. They were developed in cooperation with Pratt & Whitney engineers to meet the specific and exacting requirements of modern aircraft engine gears. These machines are equipped with a new wheel-trimming feature and a two-speed spindle drive to eliminate burning.

"Another advantage is the relative ease with which the involute profile can be modified."

Write today for Gear Grind's new, comprehensive brochure.

These Advanced Features Are Also Available:

- Simplified modification of the involute gear tooth profile.
- Automatic trimming of the grinding wheel assures uniformly accurate work.
- Available as fully automatic machines incorporating automatic loading and unloading.



THE GEAR GRINDING MACHINE COMPANY

3937 CHRISTOPHER, DETROIT 11, MICHIGAN

Manufacturers of:
The Detroit Screwmatic 750, Automatic Screw Machine.
RZEPPA ("Sheppa") Constant Velocity Universal Joints.

56-C

—ITEM 214—

The Engineer's Library

gineers, 1121 Fifteenth St., N.W., Washington 5, D. C., $1.00 per copy, or 50 cents for NSPE members.

This report presents findings of the second national salary survey conducted by the National Society of Professional Engineers. All respondents who provided this information were members of NSPE. It covers their 1954 income and draws comparisons with the 1952 statistics.

•

Metals Handbook, 1955 Supplement. 208 pages, 8¼ by 10¾ inches, cloth-bound; *published by and available from the American Society for Metals, 7301 Euclid Ave., Cleveland 3, O., $6.00 per copy to nonmembers.*

This second supplement to the 1948 Metals Handbook presents up-to-date information on 21 subjects in four general categories. The first group is titled Metals and Applications. It covers the selection of steels for formability, selection of forming die material, gray cast iron, stainless steel in chemical process industries and aluminum alloy castings.

The second category is headed Design and Application. It concerns closed-die forgings, helical springs, surface finish, residual stresses and electroplated coatings.

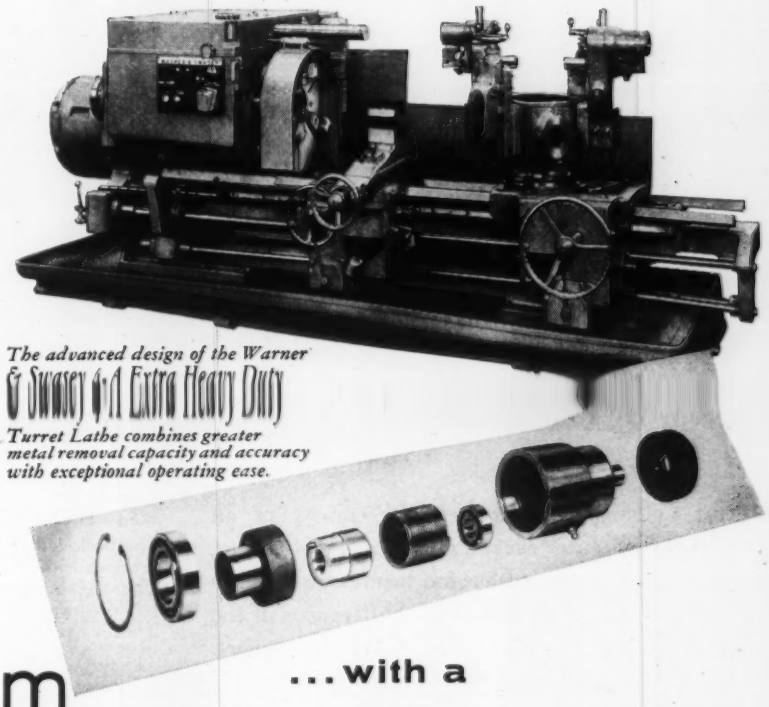
Processing and Fabrication is the third category and covers eight subjects. The fourth group, Testing and Inspection, includes three articles.

Manufacturers' Publications

Simplified Drafting. By J. H. Bergen; 36 *pages, 8½ by 11 inches, paperbound; published by American Machine and Foundry Co.; for additional information write to the author, AMF General Engineering Laboratory, 11 Bruce Place, Greenwich, Conn.*

Through the medium of sample drawings of engineering parts and assemblies, this booklet presents eleven rules for simplified drafting. Text and illustrations afford comparison between traditional and simplified methods.

Here's how WARNER & SWASEY controls coolant pump



The advanced design of the Warner & Swasey 6-A Extra Heavy Duty Turret Lathe combines greater metal removal capacity and accuracy with exceptional operating ease.

...with a Marquette SPRING CLUTCH

Dependability and *compactness* are two big reasons why The Warner & Swasey Co. uses a Marquette Spring Clutch to connect and disconnect the coolant pump on their saddle type turret lathes. The same reasons explain why Marquette Spring Clutches are used for such a wide variety of applications—from Aircraft to X-ray.

Moreover, Marquette Spring Clutches maintain their efficiency almost indefinitely . . . and they cost less than other types of clutches!

There are no restrictions on torque. Actual designs range from 6 in. lbs. to 25,000 ft. lbs. Speeds? From 1 to 10,000 r. p. m.

OVER-RUNNING or FREE-WHEELING CLUTCHES • INDEXING CLUTCHES
BI-DIRECTIONAL NO-BACK BRAKES • REVERSING CLUTCHES
SINGLE REVOLUTION CLUTCHES • DELAYED ACTION CLUTCHES

The Marquette METAL PRODUCTS CO.
SUBSIDIARY OF CURTISS-WRIGHT CORPORATION
ALSO MANUFACTURERS OF: ROLLER BEARING TEXTILE SPINDLES
HYDRAULIC GOVERNORS • PRECISION PARTS AND ASSEMBLIES
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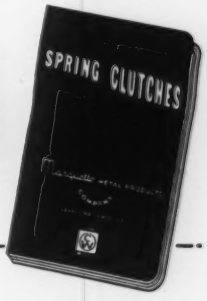
A PRODUCT OF CW CURTISS-WRIGHT



THE MARQUETTE METAL PRODUCTS CO.
1141 Galewood Drive, Cleveland 10, Ohio

Please send manual describing the functions, applications and operations of the basic types of Spring Clutches.

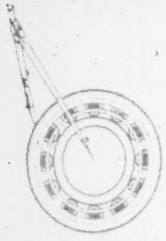
COMPANY_____

NAME_____ TITLE_____

ADDRESS_____

—ITEM 215—

Cylindrical Roller Bearing Retainers . . .



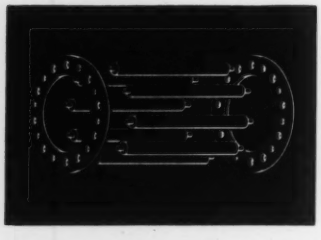
The seven basic types in current use . . . their influence on bearing cost and performance . . . why one type is best suited to your individual design requirements

Most cylindrical roller bearings consist of an inner race, an outer race, a complement of rollers, and a cage or separator which locates and guides the rollers. There are significant differences in the design and construction of these roller retainers. (The word "*retainer*" is used to designate both a cage, which retains the rollers, and a *separator* which only spaces the rollers.) Some retainers are simple and economical, well adapted for volume production, and designed for use where price is a primary consideration. Others are more costly to make but are designed for improved roller guidance, to insure cooler or smoother operation, or to provide longer life in heavy duty service.

Beginning with the most elementary, here are the seven basic types of cylindrical roller bearing retainers in current use, with a brief outline of their construction and characteristics:

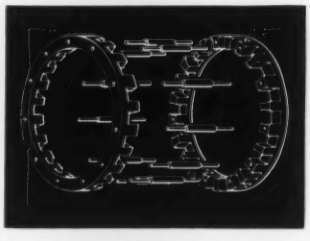
1. TRUNNIONED ROLLER CAGE

The trunnioned roller cage is used for bearings of very thin annulus, where the rollers must be small in diameter, closely spaced, and relatively long. The end rings are economical hardened steel stampings, into which the trunnioned rollers are inserted. The bars which connect the end rings are riveted to the rings at assembly so that the rollers and cage form an integral, non-separable unit. Thus, outer or inner races can be omitted if desired, with rollers operating directly on a suitably hardened shaft or housing bore. This cage is an economical design for volume production and possesses excellent operating characteristics for a wide range of applications.



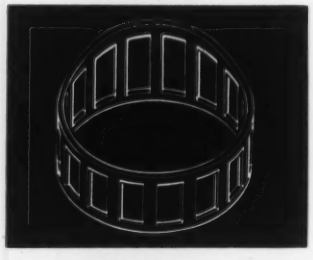
2. POCKETED END RING CAGE

The pocketed end ring cage is restricted to fairly large bore bearings with relatively long rollers. The end rings are bronze. The steel connecting bars are riveted into the end rings and the rollers operate in drilled pockets which guide them accurately. The construction has less tendency to twist or rack, and operates with less end friction because the outside faces of the bronze end rings are smooth uninterrupted surfaces. This type is known as a roller-riding cage, and makes no contact with the bearing races. It can be produced economically in small lots and since it is non-separable, bearing races can be omitted if desired. The characteristics of the pocketed end ring cage make it particularly desirable for applications where long life and heavy-duty service are required.



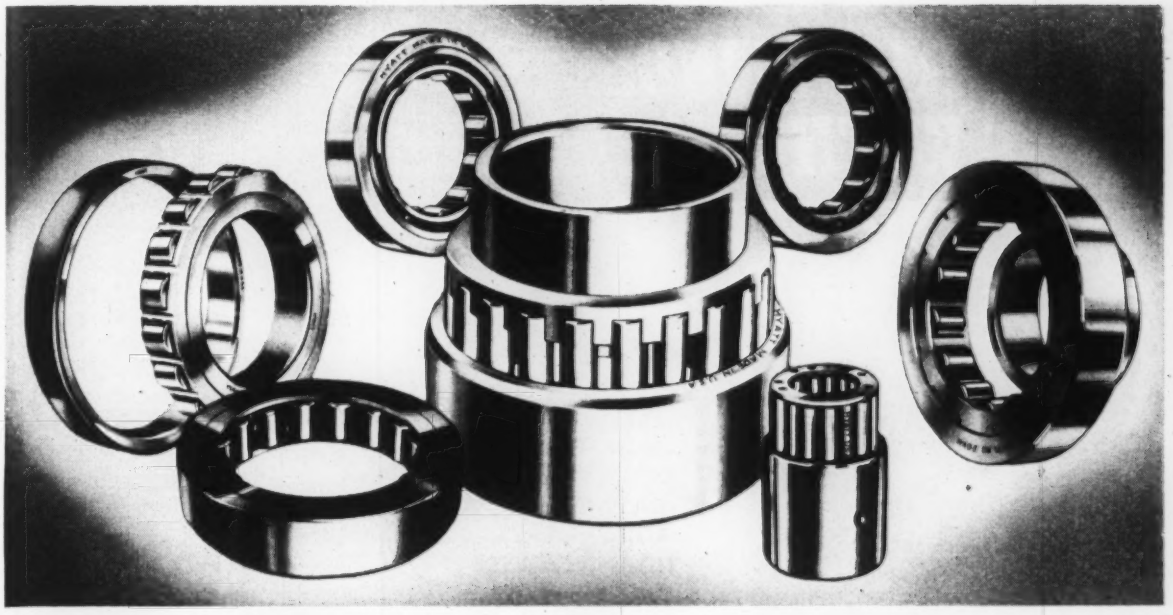
3. STAMPED STEEL SEPARATOR

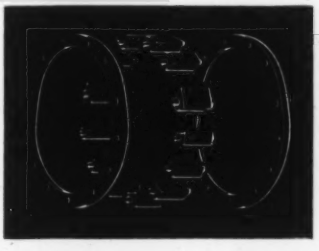
The stamped steel separator does not retain the rollers by itself, but merely separates them. It is a one-piece steel stamping with the separating bars coined to conform to the roller contour, and rides the rollers below their pitch line. Rollers are guided by the race flanges and snap rings, in conjunction with the cage bars. The simple, open design of this separator insures large grease capacity and good lubricant circulation, rendering it relatively insensitive to dirt. Since the separator is retained axially by the roller ends, there is no external requirement for axial location. The stamped steel separator is usable throughout a wide range of bearing sizes where rollers are relatively short (the Hyatt Hy-load series), and is economical for volume production.



4. FORMED BAR CAGE

The formed bar cage is built up of stamped end rings and bars formed to the roller contour. The end rings and bars are riveted together at assembly, making the race and roller assembly a non-separable unit. This cage is used on Hy-load bearings, with double-flanged inner or outer races. This

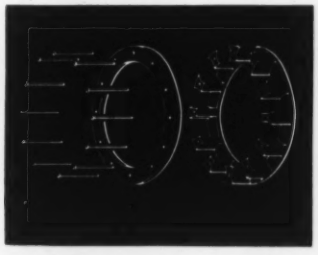




design insures quiet operation, better roller guidance, and provides a smooth contact surface between bars and rollers. This is a roller-riding design requiring no race contact in operation and is well adapted for volume production.

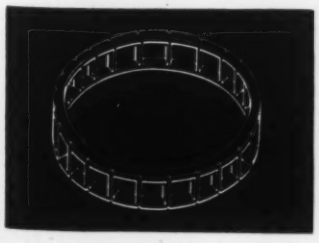
5. DRILLED POCKET CAGE

To construct this type, a bronze cylinder is drilled and reamed to form pockets in which the rollers operate. After the rollers are inserted, a flat end ring is riveted in place so that the rollers are permanently retained in the cage. This design provides extremely close control of the rollers in operation and prevents skewing which would impair both the thrust and radial capacity of the bearing. This is another roller-riding cage comprising a non-separable unit suitable for operation with inner or outer races omitted. The design insures superior performance and is used in applications requiring bearings of better than commercial quality.



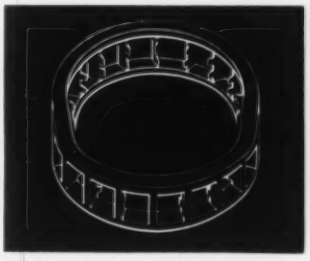
6. SEPARABLE BROACHED POCKET CAGE

This type is used only on the finest-quality bearings where performance is more important than price. It is made of one integral bronze cylinder, with pockets broached for maximum uniformity. This is the preferred type for the finest high-speed precision bearings because it insures minimum friction between rollers and separator, and allows better oil circulation for cooling at high speeds. Moreover, there are no thermal differences in this monolithic construction; the entire unit heats and cools uniformly. The separable feature offers the further advantage of roller removal for inspection of the race operating surfaces.



7. NON-SEPARABLE BROACHED POCKET CAGE

Similar in construction to the above, this design offers all the same inherent operating advantages. It is used in bearings where installation must be "blind," requiring rollers to be retained with the inner or outer race. Controlled roller drop is provided by deforming the connecting bars at assembly after the rollers are in place in the cage. This insures proper retainment but has the disadvantage that the bearing cannot be taken apart for inspection.



HYATT MANUFACTURES ALL SEVEN TYPES of cylindrical roller bearing retainers described above—each the finest of its type. You will find more details in HYATT General Catalog No. 150, or your nearby HYATT Sales engineer will be glad to help you choose the type best suited to your individual design requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT
ROLLER BEARINGS

—ITEM 216—

XUM

PACING INDUSTRY WITH RESEARCH

Chief Sandusky

FERROUS AND NON-FERROUS CENTRIFUGALLY CAST SLEEVES, ROLLS, LINERS, TUBES, RETORTS, CHUTES, RINGS, BUSHINGS, BEARINGS, ETC.

Our continuing development program is a major factor in meeting your ever increasing demands for ferrous and non-ferrous centrifugal castings. And research is a vital phase in keeping ahead of your requirements.

Precise metallurgical control is maintained throughout the entire manufacturing process to produce strong, uniform, close-grained castings which are extremely resistant to heat, corrosion, and abrasion. Excellent machining facilities for turning, boring, and drilling are also available.

You can rely on Chief Sandusky as a versatile integrated centrifugal specialist where castings are produced to your specific requirements with modern, up-to-date equipment.

C. M. Lovsted & Co., Seattle, Wash. • Tynes Bros., Birmingham, Ala. • Cordes Bros., San Francisco and Wilmington, Calif.

Chief SANDUSKY CENTRIFUGAL CASTINGS

FERROUS AND NON-FERROUS

SANDUSKY FOUNDRY AND MACHINE CO., Sandusky, Ohio

—ITEM 217—

For More Information Circle Item Number on Yellow Card—page 19

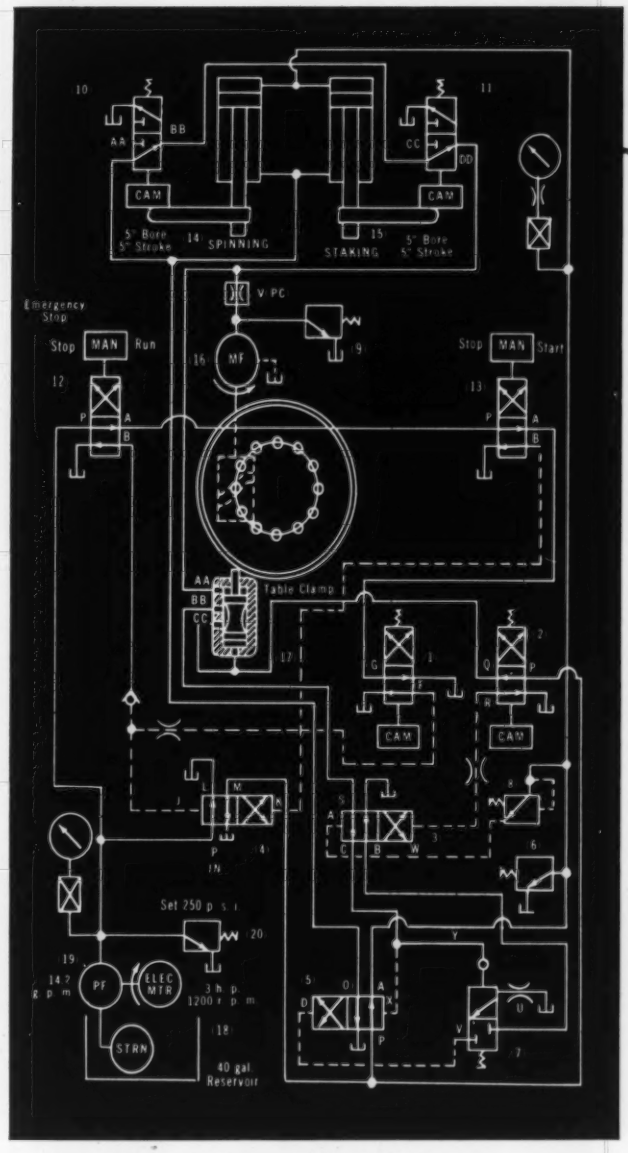
New Machines

Metalworking

Hydraulic Dimpler: Model 210-615 mobile machine for hot and cold dimpling has adjustable thrust and heat ranges. Thrust range for preforming is from zero to 15,000 lb, adjustable in 100-lb increments. For final forming the thrust range is zero to 20,000 lb. Heat range for hot dimpling is adjustable from zero through 750 F. Automatic heat timer is adjustable up to 15-second intervals. The unit accommodates 3/32-in. rivets to $\frac{3}{8}$-in. screws in light and heavy gage aluminum. It weighs 365 lb. *Manco Mfg. Co., Bradley, Ill.*

Milling Machine: The Quartet miller performs vertical, angular, universal and horizontal milling operations. It mills, drills, bores, taps, faces and counterbores a workpiece to close tolerances without the use of fixtures. In universal operation the horizontal spindle, rather than the saddle and table, indexes to the required angle. Spindle is mounted in a turret which can be swiveled 360 deg. The machine has 30-in. horizontal, 11-in. cross and $16\frac{1}{4}$-in. vertical travel. Horizontal spindle has either a No. 40 or No. 50 taper and is driven by a 3 or 5-hp motor. Power-feed vertical head is independently driven by $1\frac{1}{2}$ hp motor mounted on the rectangular overarm. Horizontal spindle speeds are variable from 29 to 1450 rpm. Horizontal and vertical spindles can be used simultaneously. Machine can be operated while the turret is being indexed. *Cincinnati Mfg. Corp., U. S. Burke Machine Tool Div., Cincinnati, O.*

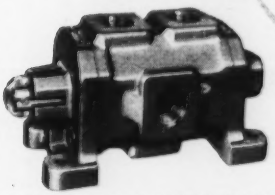
Double Disk Grinder: Model 2V18 double disk grinder simultaneously grinds two flat surfaces of small workpieces such as coil springs, carbon brushes and ceramic materials. Machine has an interchangeable rotary work carrier driven by $\frac{1}{2}$-hp, 1750-rpm motor through an adjustable-speed hydraulic transmission and speed re-



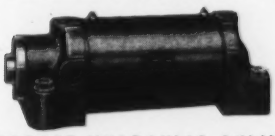
Write for FREE copy of "Circuit Rider" booklet. It explains the above circuit plus many others.

from the simplest to the most complex

specify... **Logan**

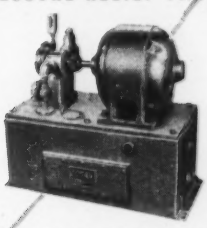


HYDRAULIC CONTROL VALVE



ROTOCAST HYDRAULIC CYLINDER

PRESSURE RELIEF VALVE



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- ☐ 100-3 Air-Draulic Cylinders
- ☐ 100-4 Air Valves
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- ☐ 100-5-1 Ultramation Cylinders
- ☐ 51 Presses
- ☐ Facts of Life
- ☐ 62 Sure-Flow Pumps
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- ☐ 200-2 Rotocast Hyd. Cylinders
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COMPANY _____
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—ITEM 218—

SAVE

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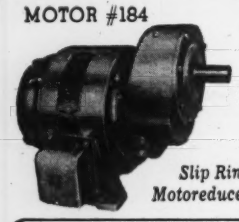
SPECIAL-MOTOR "LIBRARY"

Over 900 Different

Electric Motors

MOTOR #184



Slip Ring Motoreducer

HIGH STARTING TORQUE ON LOW CURRENT—plus variable speed reduction, are features of this Slip Ring Gear Reducer motor. Aids in getting heavy loads up to full speed through step by step starting.

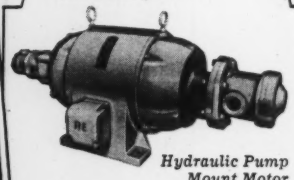
MOTOR #107

Fluid-Shaft

Motoreducer with Brake

FLUID-CUSHIONED ACCELERATION, SLOW SPEED, SPLIT-SECOND BRAKING—Internal fluid coupling provides smooth starts, prevents "jamming" of equipment. New "doughnut" magnetic brake can be mounted before or after coupling—or both.

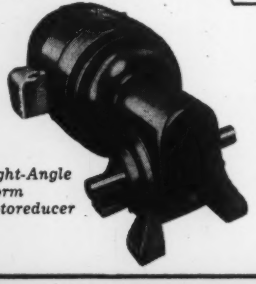
MOTOR #841



Hydraulic Pump Mount Motor

MOUNT PUMP DIRECTLY TO MOTOR'S END BELL—Eliminates usual need for separate pump-mount platform. Insures absolutely perfect alignment with pump shaft. Available with flange on one or both ends. For all standard pump makes.

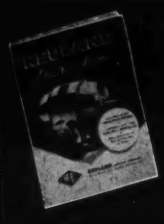
MOTOR #912



Right-Angle Worm Motoreducer

COMPACT SPEED REDUCER—This right-angle, worm type gear reducer provides lowest cost speed reduction. Mounts on floor, overhead or side. Extremely versatile, multi-shaft load hook-up. Fits tightest quarters.

REULAND'S "XPANDABLE" DESIGN MEANS ALMOST UNLIMITED ADAPTABILITY . . .



Don't pay for special motor development until you first check the Reuland SPECIAL-MOTOR LIBRARY. Reuland's revolutionary new XPANDABLE DESIGN idea has produced literally hundreds of unique power packages, one of which may already be the answer to your needs.

Reuland also produces a complete line of standard electric motors. Free engineering literature will be sent upon request. Your inquiry will be given prompt, personal attention.

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Western Division: Alhambra 17, Calif. ■ Eastern Division: Howell 17, Mich.

—ITEM 219—
For More Information Circle Item Number on Yellow Card—page 19

New Machines

ducer. Speeds from ⅛ to 1½ rpm are obtained from the carrier by adjustment of the transmission. Work guide plate is vertically adjustable to accommodate carriers of various thicknesses. Two 18-in. diam disks are independently driven by 3, 5 or 7½ hp motors. Heads can be tilted. Pushbuttons on the grinder column control motors for upper and lower spindles, rotary carrier and coolant pump. Rotary carrier diameter is 34 in. *Gardner Machine Co., Beloit, Wis.*

Testing and Inspection

Gear Checker: Model SIG-18-in. Red Ring gear checker is designed for inspection of internal spur or helical gears with pitch diam from 2 to 18 in. and maximum diam of 26 in. The unit checks tooth spacing, pitch or root diameter eccentricity and size, and parallelism of spur gears of 2 to 48 diametral pitch. Cast iron base supports the vertical work spindle. Spacing, size and eccentricity-checking head is mounted on an adjustable overarm. Parallelism checking head is mounted at the top of the base checker. Adjustable spring load advances the checking head to the tooth space to be checked. The unit occupies a floor space of 30 x 40 in. and is 40 in. high. *National Broach & Machine Co., Detroit, Mich.*

X-Ray Unit: Improved model MG 160-D Norelco x-ray unit provides either 40 or 120 deg apertures for rapid inspection of welds, pipe lines, power plants and ship and aircraft equipment. Weatherproofed tubehead provides 1.5 mm focal spot, rotatable indexing radiation diaphragm and two apertures 180 deg apart. Locking device fixes either aperture in position for use. Eccentric positioning is possible with cylinders having a minimum diam of 28½ in. Centric positioning is employed with smaller diameters. X-ray tubehead contains the high tension generator of 160,000 v output. Stepless control permits selection of voltages from 75 to 160 kv at currents up to 6 ma. Power supply is 230 v ac. *North American Philips Co. Inc., Research and Control Instruments Div., Mount Vernon, N. Y.*

The pioneer builder of machine-ground b/b screws announces a revolutionary new line of...

STANDARD-SIZED ROLLED-THREAD SAGINAW Ball/Bearing SCREWS

PRICED AS LOW AS, OR LOWER THAN, ORDINARY ACME SCREWS!

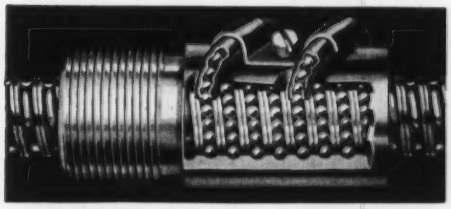
Get up to 6 times more efficiency... save at least 2/3 on power requirements or manual effort!

Here's great news for every manufacturer who uses Acme screws or hydraulic actuators in his product! Saginaw now offers Rolled-Thread *Safety b/b Screws* in standard sizes at amazingly low mass-production cost.

In many applications this new rolled-thread type will provide completely adequate performance at a fraction of the cost of machined-thread units.

GIVE YOUR PRODUCTS THESE PERFORMANCE ADVANTAGES AT NO INCREASE IN COST—

- **At least 90% efficiency guaranteed**—compared with 15% to 20% efficiency of Acme screws.
- **Requires less than 1/3 as much torque** as Acme screws for same amount of lineal output.
- **Saves substantially on cost, size and weight** of motors, gear boxes and auxiliary equipment.
- **Far less wear—less maintenance—longer life.**
- **Precision positioning**—free play can be virtually eliminated where necessary.
- **Operates dependably with or without lubrication** at temperatures from −75° F. to +175° F.



New standard Saginaw ball-nut can be furnished threaded or with flange or trunnion-type adaptors for easy application to almost any unit.

ROLLED-THREAD *SAFETY* b/b SCREWS CAN BE MANUFACTURED IN THESE STD. SIZES AND ANY SCREW LENGTH

Ball Circle Diameter	Ball Size	Lead
.375	.0625	.125
.631	.125	.200
1.000	.15625	.250
1.171	.28125	.41304
1.500	.34375	.47368
2.250	.375	.500
3.000	.500	.660

ROLLED-THREAD *SAFETY* b/b SCREWS ARE ALREADY BEING SUCCESSFULLY USED IN THESE TYPICAL APPLICATIONS.

- Automatic Garage Doors
- Automobile Seat Adjusters and Window Lifts
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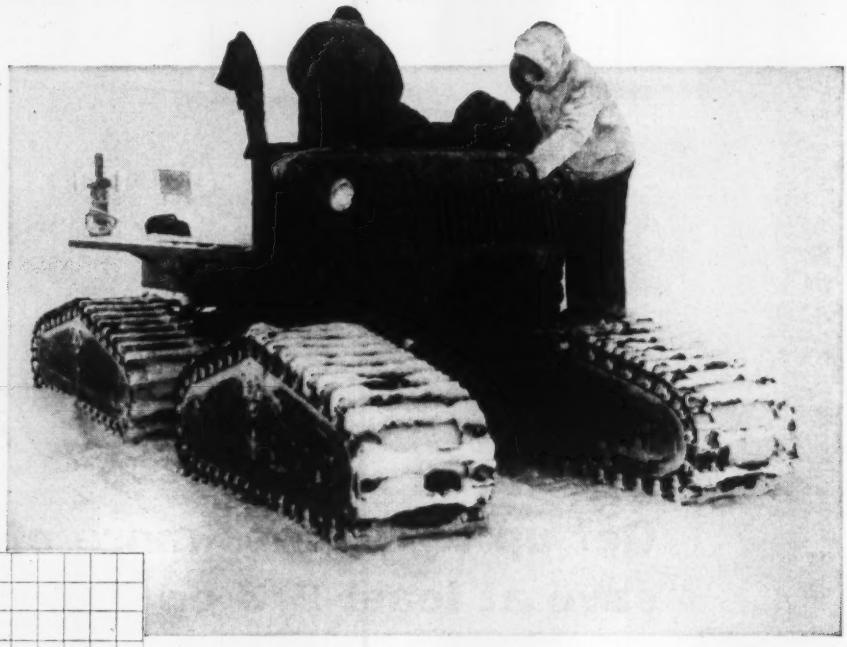
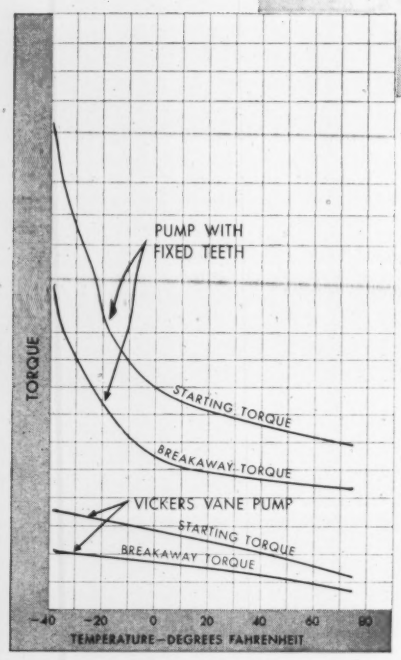
Safety ball bearing Screw by Saginaw

—ITEM 220—

MUCH EASIER COLD WEATHER STARTING



Sno-Cat (without body) undergoing tests in extreme cold in the Pyrenees mountains preparatory to being used by French scientific expedition at the South Pole. Sno-Cats will also be used by the U.S. Navy and British Expeditions to the Antarctic.



Curves based on comparative tests of a Vickers Balanced Vane Type Pump and an equal capacity pump with fixed teeth. Oil used in both was SAE 10W premium grade.

Another Reason Why

TUCKER SNO-CATS have

VICKERS® Balanced Vane Pumps

The Sno-Cat operates where it is really cold . . . high in the mountains . . . with U. S. Navy, French and British Expeditions in the bitter wastes of the Antarctic . . . wherever snow is so deep that wheel vehicles fail.

Like many other vehicles that must operate in cold weather, the Sno-Cat uses a Vickers Vane Pump to avoid the extra starting handicap that would be imposed by a hydraulic pump with fixed teeth or spring-extended vanes. In extremely low temperatures such a pump seriously increases starting load over normal (see curves at left) . . . at a time when the cold has substantially reduced the power of the starting battery. The diagrams below at the left show why Vickers Vane Pumps provide much easier cold weather starting.

All Tucker Sno-Cats use a Vickers hydraulic power steering system. In addition to the pump, these systems include a steering booster, a volume control, and overload relief valve.

Any vehicle which must operate in cold weather needs a hydraulic pump that provides "no-load starting". Let us tell you more about it . . . and about the many other reasons for using Vickers Balanced Vane Pumps.

Schematic diagram of Vickers Balanced Vane Type Pump showing how sliding vanes are retracted at normal engine cranking speeds. No oil is pumped and there is practically no starting load.

Similar diagram shows how pump vanes are extended when engine fires. Pumping then begins and continues at all engine speeds (vanes are held in intimate contact with cam ring by system pressure in addition to centrifugal force).

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
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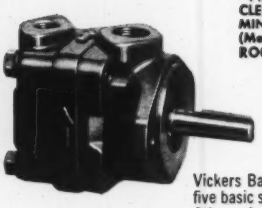
Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE ST. LOUIS • TULSA • WASHINGTON • WORCESTER
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto



Vickers Balanced Vane Type Pumps for mobile equipment are available in five basic sizes having 15 normal delivery ratings and a variety of mountings. Other advantages include: high efficiency, automatic wear compensation, hydraulic balance, dependability and long life. Write for Catalog M-5101.

7376

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

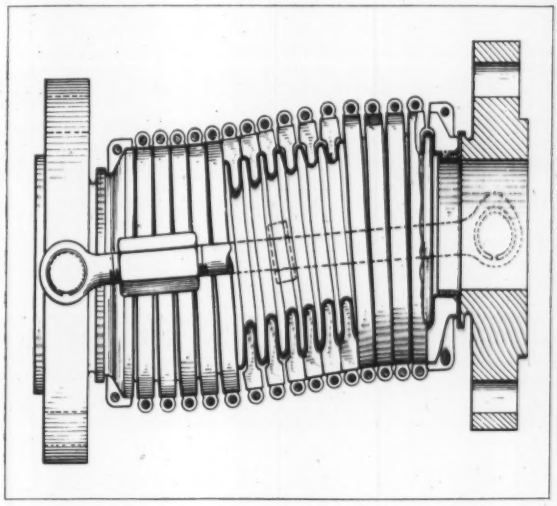
—ITEM 221—
For More Information Circle Item Number on Yellow Card—page 19

NOTEWORTHY

Patents

Reinforced Bellows Joint

Airtight flexible bellows connections between two sections of movable hose or pipe may be protected against damage by a series of steel reinforcing rings. These rings, each consisting of two circular half sections, are fitted around the outside of the bellows and

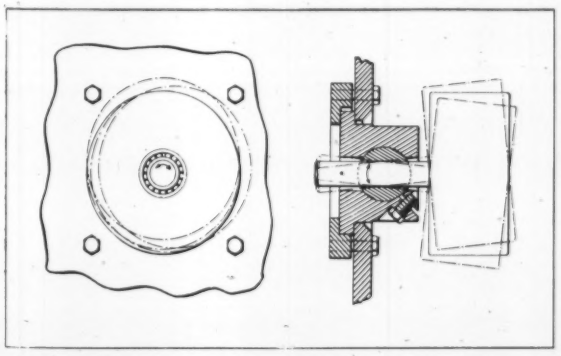


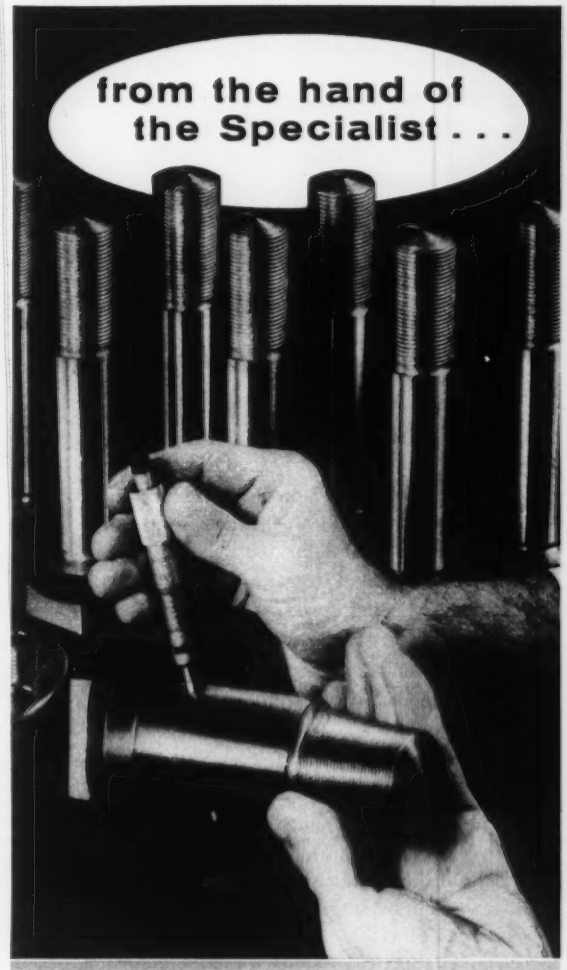
rest in the convolutions. Bellows movement is limited to a safe value by interference between adjacent rings. In addition to preventing rupture, the rings equalize stresses in the bellows. *Patent* 2,707,117 *assigned to Chicago Metal Hose Corp. by D. W. Fentress and F. S. Schindler.*

Adjustable Pulley Mount

Proper alignment of a pulley or idler to compensate for tracking errors is possible with a mounting arrangement having three adjustments: axial, vertical tilt and horizontal tilt. One adjustable component consists of a cylindrical member whose axis of rotation is at right angles to the pulley shaft and

(*Continued on Page* 152)





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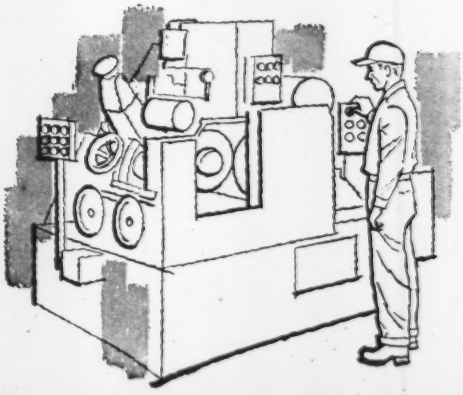
BARIUM STEEL CORPORATION
WORKING IN STEEL, ALUMINUM MAGNESIUM, FIBERGLASS

ERIE BOLT & NUT CO.
Erie, Pennsylvania
Representatives in Principal Cities

--ITEM 222— Next Page—ITEM 223

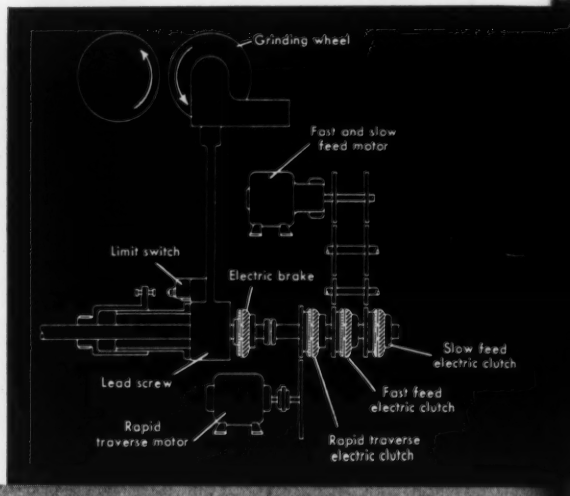
HOW LOW-COST AUTOMATIC TRANSMISSION SIMPLIFIES CONTROL OF COMPLEX MOTIONS

Warner Electric Brakes and Clutches provide automatic power link in gear box of machine tool

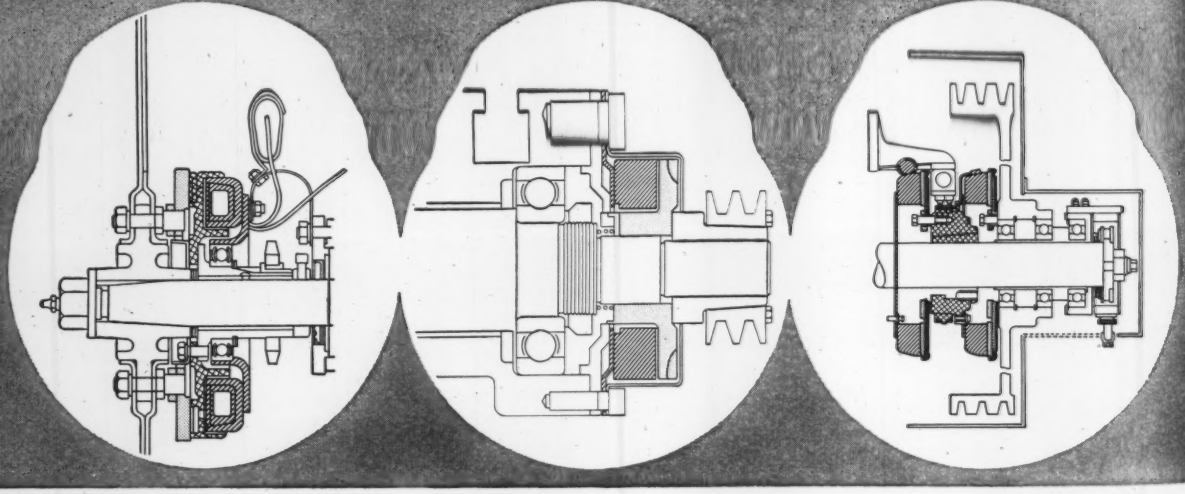


The six-stage automatic cycle of this machine is electrically controlled by four Warner units. Three electric clutches and one electric brake are mounted on the input shaft and wired through the control panel to limit switches and pushbuttons. By automatically energizing and de-energizing the clutches, speed of the feed screw drive is changed without shifting gears. Electric actuation is instantaneous, and there is no time lag for engagement or release of the clutch and brake units. Once the machine is started, it completes the grinding cycle automatically.

Easily wired into standard machine circuits, Warner Electric Brakes and Clutches permit you to use a variety of automatic controls for stopping, starting, inching and jogging, positioning, interlocking, and synchronizing machine motions for fast, foolproof operations. Electromagnetic principle permits accurate modulation of torque and actuation time. High torques can be applied more easily, more quickly, and more precisely than ever before.



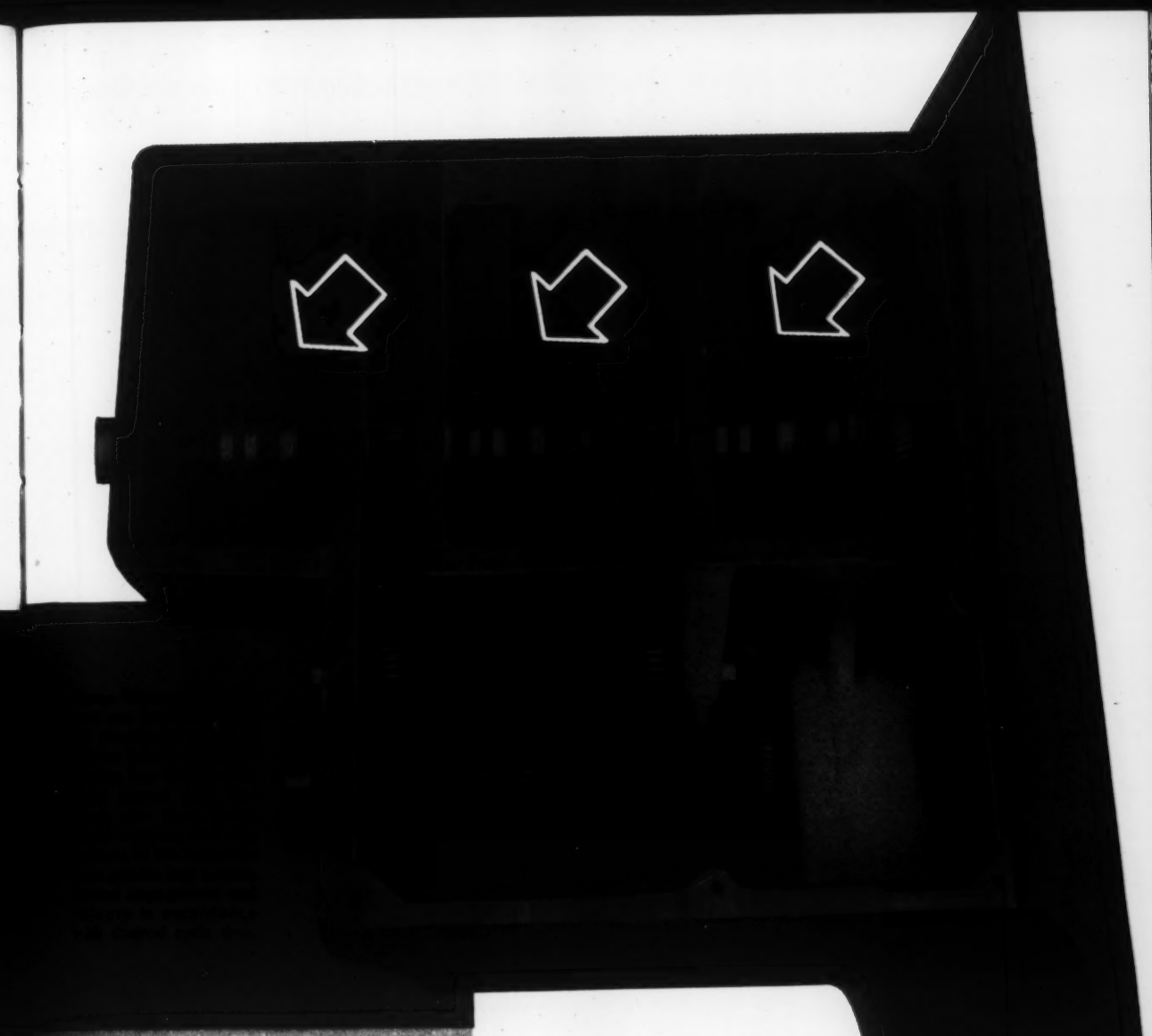
EASILY SOLVE POWER PROBLEMS LIKE THESE



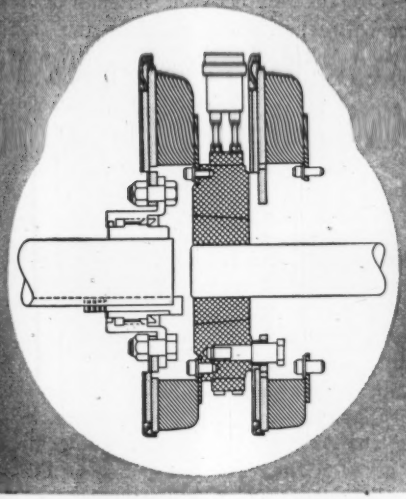
Electric Clutch for Grain Combine—Armature is mounted on drive pins to hub keyed to beater shaft. Rotor between armature and magnet is bolted to feeder drive sprocket hub. When stationary-mounted magnet is energized, flux passes through rotor and armature, which lock and engage platform drive. Remote control from operator's station permits instantaneous disconnect in the event foreign material enters the platform.

Electric Brake for High Speed Molder—Pulley drive is from motor to jack shaft, to which brake armature is mounted by splined connection. Shaft passes through the magnet, which is flange-mounted to stationary machine casting. The magnet is energized by pushbutton, and the brake stops the jack shaft, cutter, pulleys, and motor in three seconds from speed of 7200 rpm. Former braking time was five minutes.

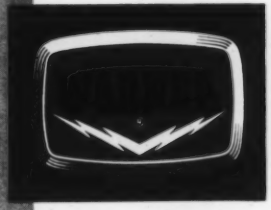
Electric Clutch-Brake for Textile Machine—Clutch is mounted on cam shaft and to inside face of free-running sheave. Brake magnet is mounted to machine casting, and armature to clutch magnet mounting hub. Electric brake is instantly engaged when clutch is deenergized, automatically stopping the warp beam. The sheave and clutch armature run freely on precision bearings until the start button is actuated.



Three Warner Electric Clutches, above, are mounted on the input shaft of the gear box. Armatures are mounted on drive pins to free-running gears on the through shaft. Magnets are mounted to hubs keyed to the shaft. Speed changes are made by engaging and disengaging gears which are in constant mesh.



Electric Clutch-Brake Coupling for Machine Tool—Mounted as a clutch-coupling between the motor and main drive spindle, the clutch and brake control rapid cycle and permit continuous operation of the motor. Brake armature is mounted to magnet mounting hub of clutch-coupling, attached to motor shaft. Brake magnet is mounted to motor housing. Clutch armature is mounted to driven shaft by gear-type hub. Stopping time is one second.



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ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

Send for new bulletin describing 21 ways Warner Electric Brakes and Clutches are used to modernize machine drives.

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2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line.

Address Dept. MD-56.

SOUTHWEST PRODUCTS CO.
DUARTE, CALIFORNIA

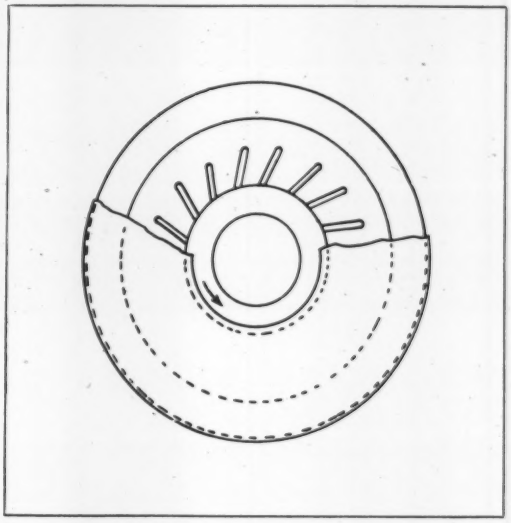
Noteworthy Patents

(*Continued from Page* 149)

is adjustable to compensate for misalignment in the vertical plane. An adjustable clamping ring compensates for misalignment in the horizontal plane. Provision is also made for adjustment of the pulley or idler shaft to correct axial misalignment. *Patent* 2,711,299 *assigned to Planet Products Corp. by T. E. Dugle.*

Overrunning Clutch

Torque is transmitted in only one direction of rotation by a clutch with rubber "sprags". Mounted between concentric raceways, a rubber ring is in frictional contact with the outer, or driving, raceway. Radial slots in the ring slightly inclined from the inner diameter, cause the ring to grip the inner, or



driven, raceway in one direction of rotation, thus engaging the clutch. In the opposite direction of rotation, the portions of the ring between the slots bend to relieve friction between the two elements and the clutch does not engage. *Patent* 2,707,038 *assigned to Formsprag Co. by L. T. Szady.*

Rotary Vane Pump

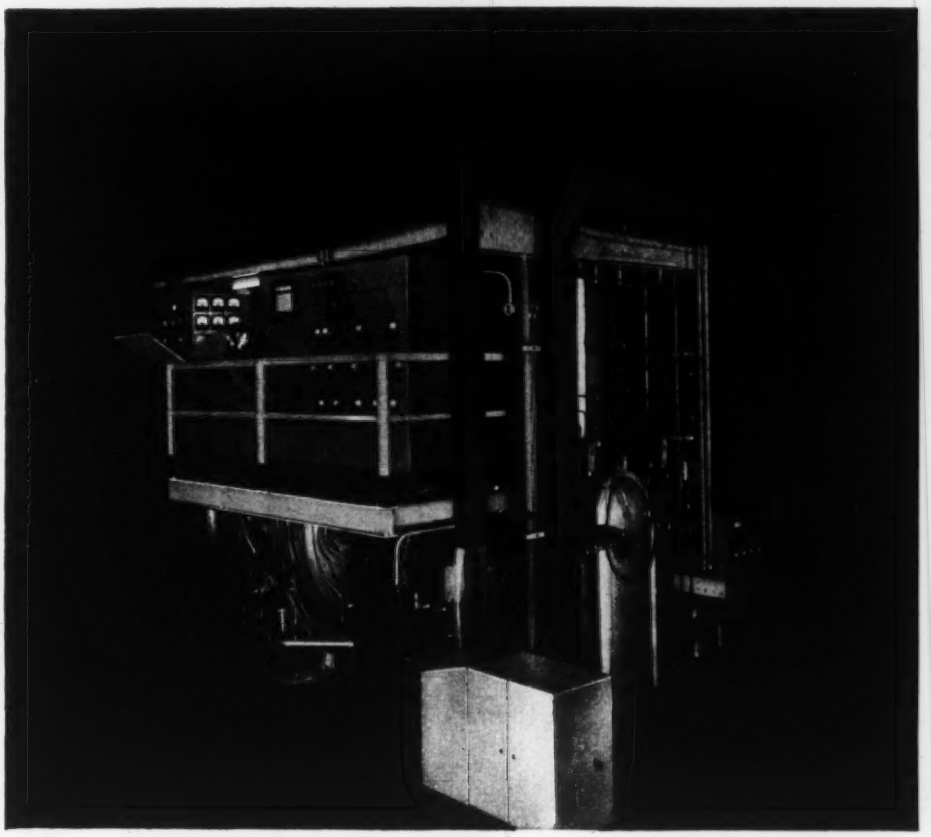
Fluid flow is utilized to assist pumping action of spring-loaded vanes in a rotary pump design. As each vane is forced inward on the return cycle by the cam action of the pump housing, suction pressure of the pump inlet acts through a groove to assist vane movement and thus reduce the frictional drag forces at the housing walls. When the vanes reach the maximum withdrawal position the suction pressure is cut off permitting the spring action to maintain sealing engagement between the vane and housing. *Patent 2,705,459 assigned to Wm. M. Wilson Sons Inc. by L. Dunning.*

Helical Spring Clutch

Engagement of the coils of a helical spring clutch unit is accomplished by a novel expanding shaft con-

—ITEM 224—
For More Information Circle Item Number on Yellow Card—page 19

NATION'S LARGEST VACUUM FURNACE POURS INGOTS UP TO 2500 POUNDS



SYRACUSE, N. Y. – Vacuum Metals Corporation has completed testing and evaluation of the newest and largest vacuum furnace in the country. Capable of producing up to 2500 pounds of vacuum-melted metal per heat, this furnace will make possible the production of larger rolled forms than ever before, as well as an increased number of smaller rolled forms from a single heat.

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Details on the applications of vacuum-melted metals are available through any branch office of Crucible Steel Company, or directly from Vacuum Metals Corporation. In requesting information, please include as detailed a description as possible of the application in which you are interested. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

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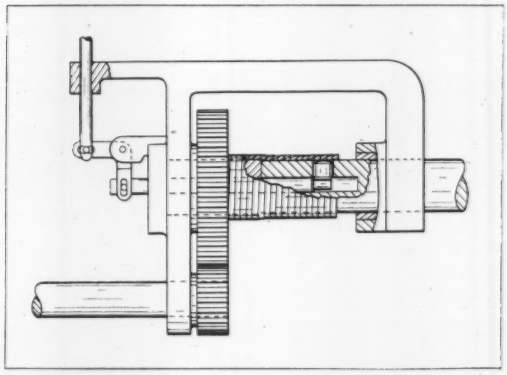
—ITEM 226—

Noteworthy Patents

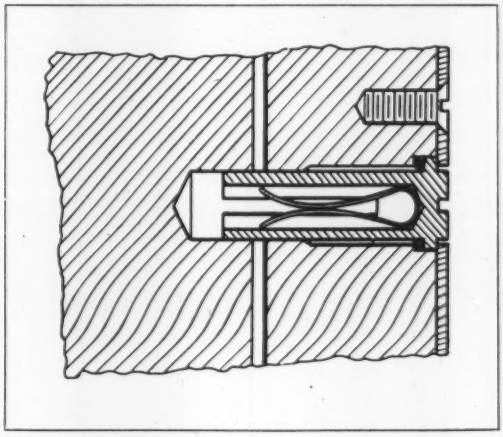
struction. A push rod, mounted axially in a bored passage in the driven shaft, actuates a pin that moves radially to project beyond the shaft surface. As the pin moves outward, it engages and expands several of the surrounding spring coils, causing the remainder of the coils to grip the shaft and thus



engage the clutch. Movement of the rod back to normal drops the pin flush with the outer diameter of the driven shaft. In this position, the helical spring coils return to their normal position and the clutch is released. *Patent* 2,705,065 *assigned to Champion Motors Co. by D. D. Kloss.*

Shut-Off Valve

On-off control of low-pressure pneumatic systems is accomplished with a slotted nylon plug fitted in a housing which is part of the pressure line. By turning the plug so the slot lines up with the pneumatic passages, free flow is permitted. Rotation of the



plug 90 degrees shuts off the flow. A hairpin spring in the slot forces the legs of the plug against the side walls of the housing to minimize leakage. *Patent* 2,707,092 *assigned to Foxboro Co. by H. L. Bowditch.*

Copies of the patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

Motor cars of tomorrow will be swift and silent beyond belief, powered by the mightiest forces man can employ. Perhaps this power is nuclear, perhaps from a chemical fuel. From either will come the "release explosion"—a swirling "ball of fire"—pure energy to be contained, controlled, delivered to the wheels.

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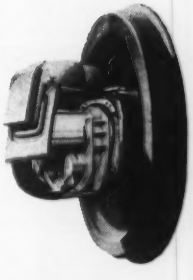

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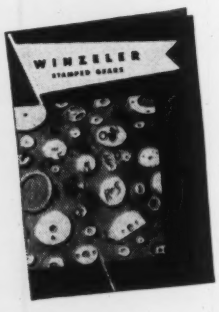

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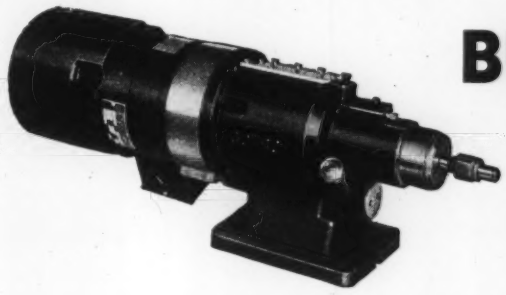

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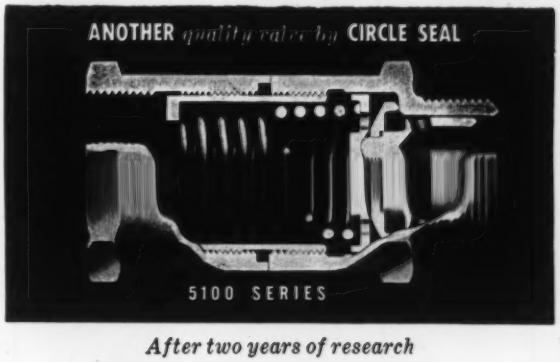

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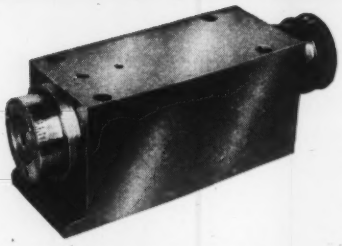

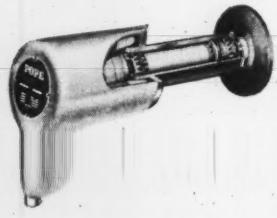

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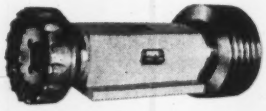

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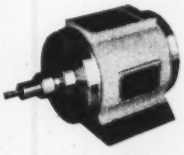

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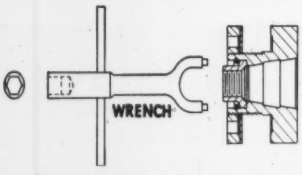

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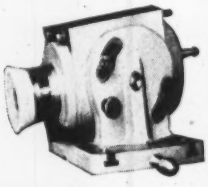

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POPE MACHINERY CORPORATION
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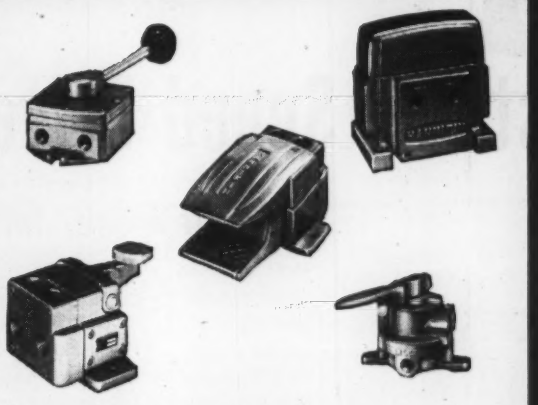

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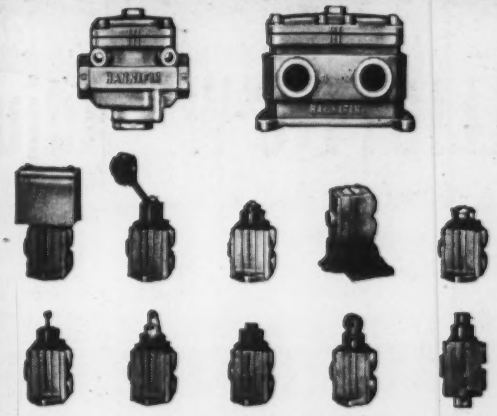

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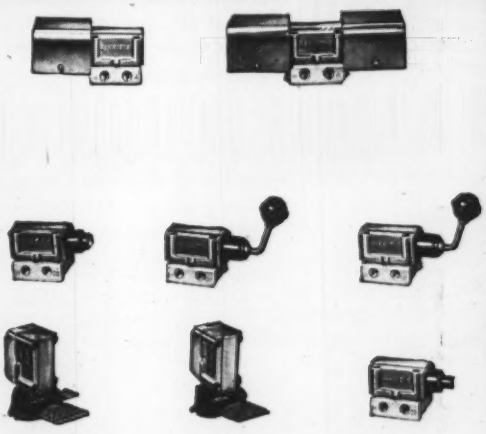
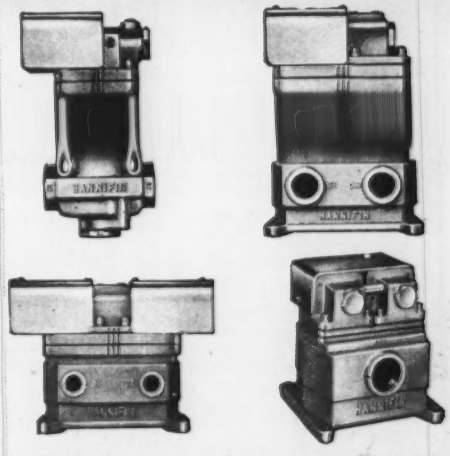


Hannifin P-M Direct-Operated 4-Way Valves. Small, compact, inexpensive. For every type operation.



Hannifin P-M Pilot-Master Valves. Solenoid controlled by integral pilot heads. 2-way, 3-way and 4-way.

HANNIFIN has the Air Control Valves for Your Specific Applications

Hannifin has the air control valves you need for use on your production lines or on the products you manufacture, often in a choice of types.

Shown here are typical valves from the extensive and complete Hannifin line. There's a Hannifin valve for every use from the simplest to the most complicated air-operated circuit. Singly or in combination, Hannifin valves provide hand, foot, cam, pressure or solenoid operation...in almost every pipe size.

You can simplify your air control valve problems by standardizing on Hannifin. Why not discuss your requirements with your Hannifin Field Engineer?

HANNIFIN

STOCK DELIVERY ON ALL HANNIFIN VALVES—MAIL THE COUPON

☐ Have Field Engineer call at once

☐ Have Field Engineer stop by soon

☐ For the present, just send complete Hannifin Control Valves Catalog

Hannifin Corporation, 515 S. Wolf Rd., Des Plaines, Illinois

Name.....*Title*.....

Company.....

Address.....

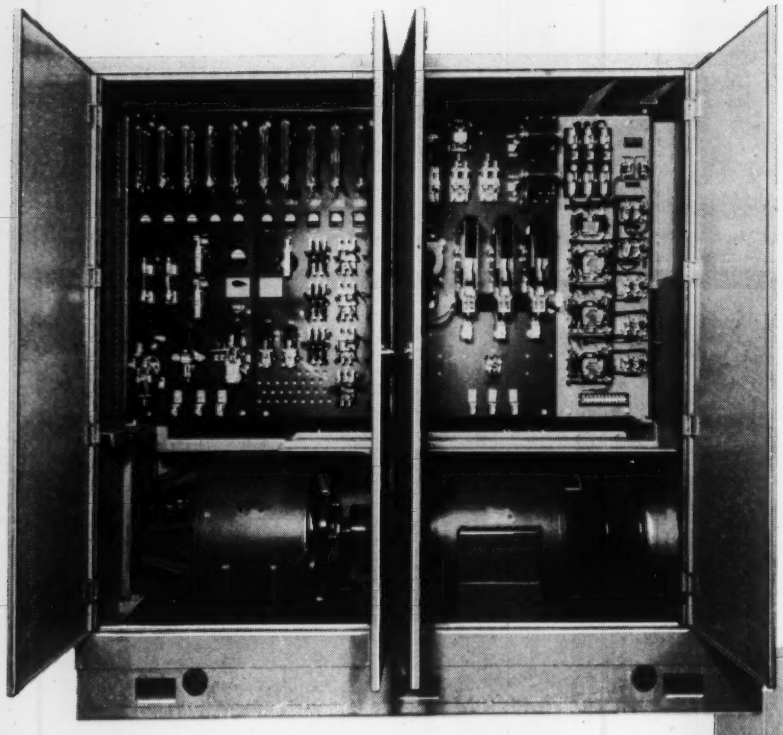
City.....*Zone*.....*State*.....

—ITEM 236—

PACKAGED ELLIOTT C-W Adjustable Speed Drives

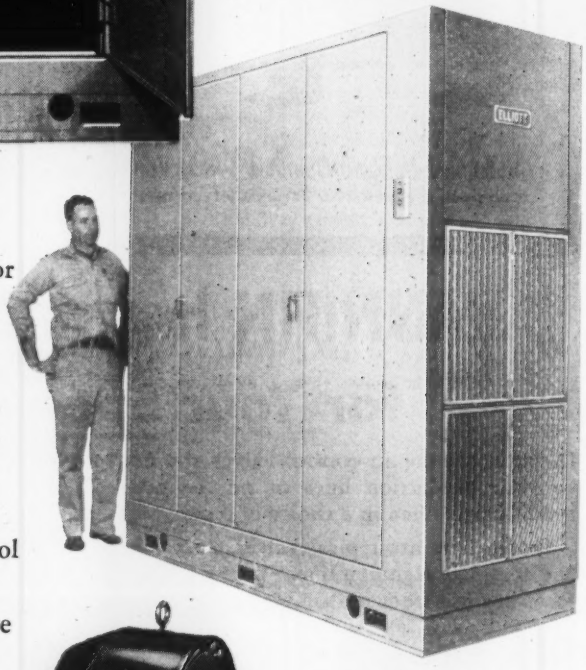
are your answer for...

- Speed Adjustment
- Positive Stopping
- Reversing
- Dynamic Braking
- Pre-set Speed
- Multi-motor Drive
- Jogging or Creep Speeds
- Automatic Acceleration or Deceleration
- Torque Limit Protection
- Visual Speed Indication
- and many other complex operating conditions



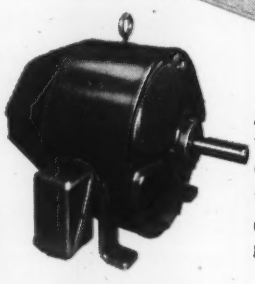
A control cabinet houses the a-c to d-c conversion unit, plus the control required for the particular application. At left is a 100-hp package.

Power unit is housed in a pressurized sheet-metal cabinet with incoming air passing through filters, insuring long life and low maintenance costs. Cabinet has doors, front and rear, for easy access; doors, as well as center posts, are removable.

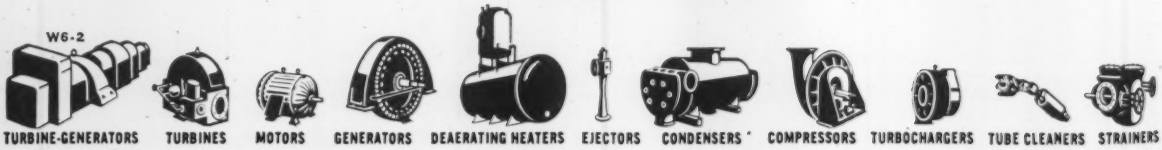


THESE PRE-ASSEMBLED, PRE-WIRED, easily installed power packages meet today's needs for flexible d-c motor performance from a-c power supply. They are designed for ratings up to 200 hp; speed ranges to 16:1 and up; 208, 220, 440 or 550 volts; 25, 50 or 60 cycles; 2 or 3 phase operation. Many modifications can be provided to meet special operating conditions. All components—power conversion and control—are backed by the Elliott Company's more than half-century experience in the manufacture and application of industrial drives. For complete information, write Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.

ELLIOTT Company



A typical Elliott C-W d-c motor for use with adjustable speed drives. In addition to dripproof (shown) Elliott offers totally-enclosed, integral brakemotors and gearmotors.

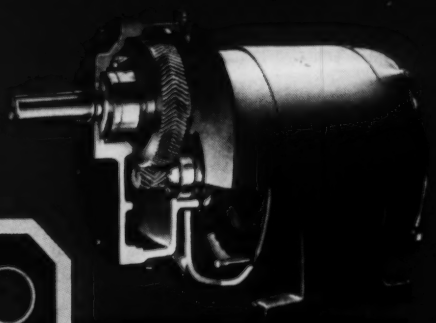


Write your own ticket—

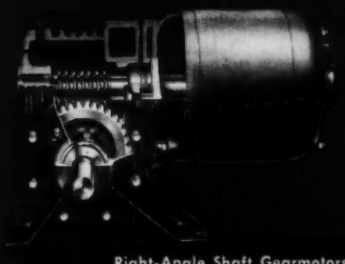
MASTER
ALTERNATING CURRENT MOTOR

SERIAL	✔		STYLE	✔	
TYPE	✔	FRAME ✔		H.P.	✔
VOLTS	✔		CYCLES	✔	
AMPS.	✔		PHASE	✔	
R.P.M.	✔		SERVICE FACTOR	✔	
CODE	✔	TEMP. RATING ✔			
SP	✔				

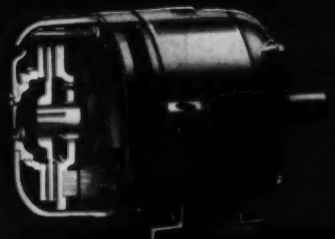
MANUFACTURED BY
THE MASTER ELECTRIC CO., DAYTON, O., U.S.A.
62916 PATENTS PENDING



Parallel Shaft Gearmotors

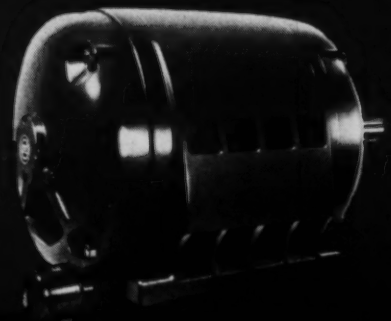


Right-Angle Shaft Gearmotors



Unibrake Motors

Speedrangers



Standard Motors—⅛ to 400 H.P.

What are your power drive requirements? Here at Master, with the widest selection in the nation to choose from, you're sure to fill your needs quickest and best.

Need something special in gear reduction—electric brakes—variable speed operation—fluid drive or special mounting? Or would some of our standard models (⅛ to 400 H.P.) fill the bill? You'll find the answer here! And remember, all Master components are engineered to form combinations of units in one streamlined, compact package of efficiency. Name your need and the name that fills it is Master—for greater salability of motor driven products; for increased productivity of plant equipment.

Motor Ratings..⅛ to 400 H.P. All phases, voltages and frequencies.

Motor Types.....Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.

Construction ....Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.

Speeds .....Single speed, multi-speed, and variable speed.

Installation .....Horizontal or vertical, with or without flanges and other features.

Power Drive Features .....Electric brakes (2 types)— 5 types of gear reduction up to 432 to 1 ratio. Mechanically and electronically-controlled variable speed units—fluid drives—every type of mounting.

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO

How high load capacity is built into less space

in Dodge-TIMKEN All-Steel pillow block

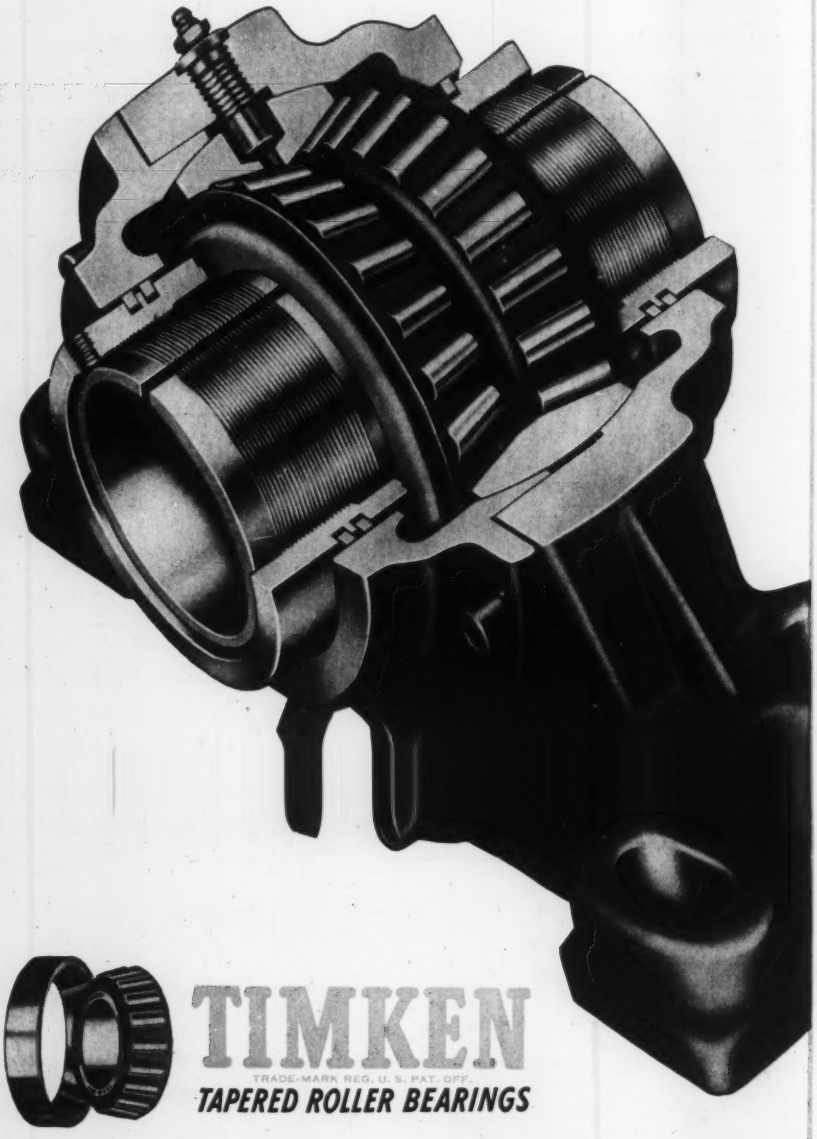
THIS rugged Dodge-Timken pillow block packs more capacity in less space than ever before. All-steel construction gives it extra strength and durability. The design is compact. No special thrust devices that take up extra space are needed—the two-row Timken® tapered roller bearing takes *both* radial and thrust loads in any combination. And full line contact between the rollers and races assures high load capacity.

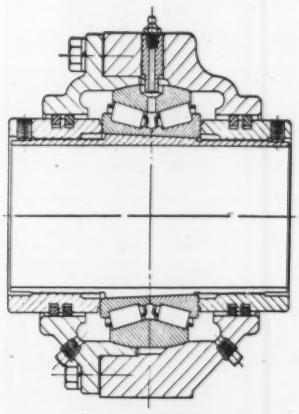
The cutaway view below shows the bearing. It is of special design, with tapered bore and self-aligning spherical outer surface—never requires adjustment. As in all Timken bearings, races and rollers are case-carburized and have tough, shock-resistant cores under hard, wear-resistant surfaces. Under normal conditions, the Timken bearing will last the life of the machinery with which the pillow block is used.

In addition to the all-steel pillow block shown here, Timken bearings are also used in the Type "E", Double-Interlock, Type "C", and Special-Duty pillow blocks—other versatile pillow blocks in the Dodge-Timken line with a wide variety of uses in industry.

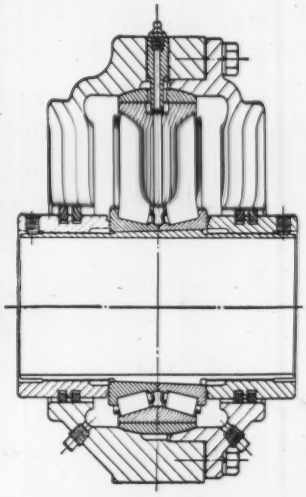
To be sure of the finest bearing steel, we make our own—America's only bearing manufacturer that does. No other bearings can give you all the advantages you get with Timken bearings. Include them in your design plans... specify them for the machines you buy or build. Look for the trade-mark "Timken"—it's on the bearing that makes any machine run better. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO".

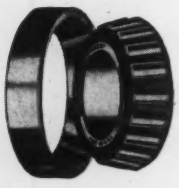
This symbol on a product means its bearings are the best.





How **DODGE MANUFACTURING CORPORATION,** Mishawaka, Ind., mounts Timken bearings in the Dodge-Timken All-Steel pillow block. Above: non-expansion block with fixed bearing. Below: expansion block with floating bearing.





TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST ▯ LOADS OR ANY COMBINATION ✳

—ITEM 153—

For More Information Circle Item Number on Yellow Card—page 19

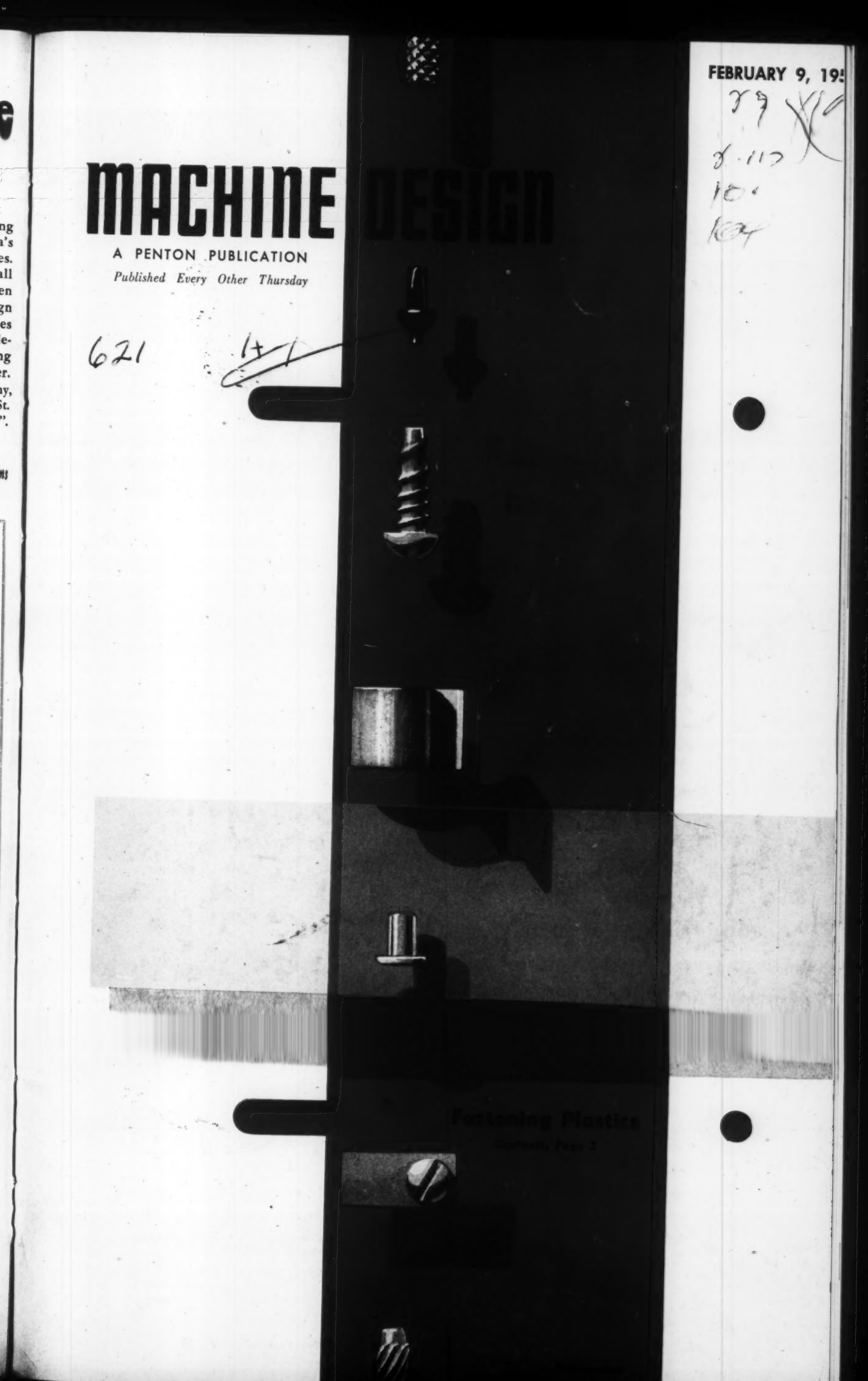
FEBRUARY 9, 19

MACHINE DESIGN

A PENTON PUBLICATION

Published Every Other Thursday

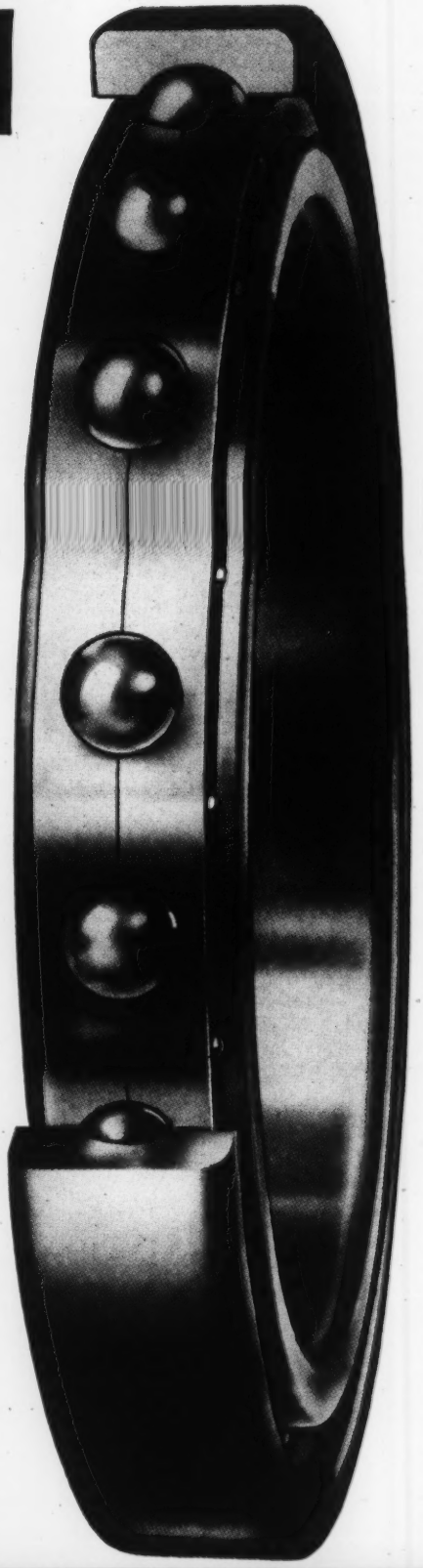
621



Fastening Plastics

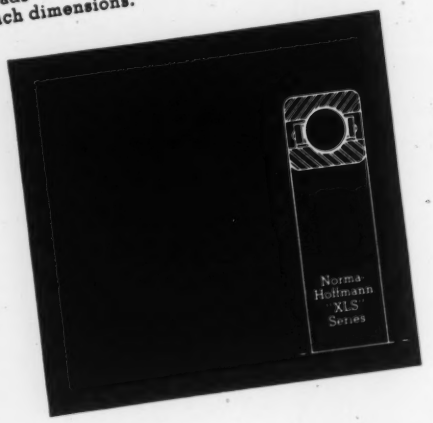
NORMA-HOFFMANN'S

Extra Light Ball Bearing



"XLS" Series Aids Designers Where Space is Limited

In many cases where friction-free operation must be had in extremely restricted space, these Extra Light Ball Bearings by Norma-Hoffmann have been the only solution. The "XLS" Series (in bore sizes below 1⅜" called the "S" Series) provides a range from ⅛" to 22½" bore. These bearings are self-contained, non-separable and are suitable for combined radial and thrust loads in either direction. They are made to inch dimensions.



FEATURES

1. Have unusually large bore compared to outside diameter.
2. Are compact, light in weight.
3. Allow greater latitude in design.
4. Provide utmost in accuracy, rigidity, load capacity and friction-free operation.

NORMA-HOFFMANN
***Precision* BEARINGS**

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD, CONNECTICUT—Founded in 1911
FIELD OFFICES: Atlanta, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Kansas City, Los Angeles, San Francisco, Seattle

new JIC Solenoid and Cover!

Available on 700 Series Ross Air Valves when specified or may be installed on valves now in your plant.

- Cover protects solenoid against dust, splashing liquids and airborne contaminations.
- Can be manually operated without removing cover.
- Ample wiring connection space.
- Ring type pressure connectors.
- Interchangeable with standard Ross cover and solenoid.
- Valve becomes electrically inoperative when cover is removed.
- Captive type cover fasteners.
- Chain to prevent loss of cover.
- Threaded electrical conduit connection.
- Provision for piped exhaust.

- JIC Solenoid Cover and Head Assembly also available for 700 Series Momentary Valves.

Tomorrow's EnginAIRing Delivered Today . . . Anywhere

Control

Ross OPERATING VALVE COMPANY

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